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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

HEREDITY AND ENVIRONIC FORCES[1]

THAT the qualities and forms of living things are the final and net result of the action of environic conditions upon ancestral protoplasm is almost universally agreed upon. Unanimous as may be the acceptance of this all-inclusive generalization, yet when the attempt is made to establish the causal connection between organisms and the forces concerned in their development, an accumulation of facts is encountered which lends itself to widely divergent theoretical explanations.

No gain would result from a citation of these countless theories or from a rehearsal of the evidence claimed for the support of each of them. A proper approach to some of the results to be presented, however, makes necessary a preliminary consideration of some of the basal and recognized relations of the cell, or of the organism to the developing complex of external forces. Foremost among the problems that present themselves in such a review is that of the nature of the so-called adaptations. Underlying the practise and extension of botanical science is the untested assumption that, for example, when a mesophyte is grown as a xerophyte, the modifications of structure which ensue are adaptive and fit the organism for dealing with arid conditions. The size and form of leaves de-

[1] Address of the vice-president and chairman of the Section of Botany, American Association for the Advancement of Science, Chicago meeting, 1907–8.

veloped in such cases is determined by the balance of water supply, conducting capacity of the shoot, and the transpiration rate. The combined action of these factors does lead to the formation of organs in many instances that have the aspect of being of increased fitness and efficiency, but results of the opposite character are encountered. Thus, in my own experiments with *Roripa*, the American watercress, it was seen to bear filiform, dissected leaves when submerged, linear dissected leaves when emersed, but when acclimatized at the Desert Laboratory, developed broadly ovate, almost entire, laminæ.

Etiolation resulting from diminished illumination or total deprivation of light has been supposed to induce adaptive elongation of stems and petioles by which the chlorophyll-bearing tissues were carried past obstacles which cut off the light. Long-continued experimental studies have demonstrated that not half of the species tested exhibit such elongation, a greater number showing thickened organs, and other useless alterations.

Illustrations might be multiplied, and a candid estimate of the alterations undergone by the organs of a plant when it is subjected to unusual conditions of temperature, moisture, food-supply and seasonal change usually fails to reveal anything more than a coincidence of direct response and useful purpose, and it is evident that such coincidences must be subjected to the closest scrutiny before being accepted as adjustments conditioned by suitability.

Turning now to structures and functions of a specialized character, normally heritable and characteristic, it is easy to read into them a fitness not actually present, or not possible of causal induction by the factors to which they are supposed to be an adaptation. Thus but recently the investigations of Lloyd complete the proof that the movements of stomata are not adaptive or regulatory with respect to transpiration. Reams have been written as to the automatic and finely balanced valve-like action of these organs with respect to the conservation of water in the plant, yet it is now known that they open, widen and close in response to other stimuli rather than those arising from the turgidity of leaves and the aridity or humidity of the air. The presence of spines and spiculæ on cacti serve to check the depredations of grazing animals, but it would need a devious logic to conjure up a causal relation between the two. These structures are probably due to aridity, but are not in themselves a useful structure in adaptation to this condition: a dozen species of cacti, devoid of spines altogether, are known which live under the most accentuated desert conditions. Morgan also concludes that the capacity of regeneration has been developed without regard to any directly adaptive action, and this exemplification might be extended indefinitely if space permitted. It is not intended to assert the non-existence of direct useful alterations in the organs of plants, and of the functions they serve: Instances of apparent validity are numerous, particularly in rhythmical activities of all kinds, but the entire matter of causal adaptation is in need of a basal reinvestigation from an entirely new view-point.

This leads to a second problem most readily suggested by the time-worn phrase "inheritance of acquired characters," a conception so vague, so widely inclusive and withal so illy consonant in ordinary usage with the facts, that it will soon be quoted only for its historical importance. If by this phrase is meant that an organism makes adaptive response to its environment by adjustments of functions followed by alterations of structure, and that the con-

tinuance of the stimulus and of the response results in heritable and irreversible modifications, we have an idea resting upon inference, and based upon suppositions and circumstantial evidence only, since no satisfactory proof has yet been offered to show that a modified soma might impress its divergent characters upon the germ-plasm.

It seems necessary to repeat and emphasize the assertion that no case exists, in which it has been demonstrated, or proved beyond reasonable doubt, that any fully and continuously heritable change has been induced in a plant by the conditions of cultivation, outside of those due to selection, hybridism and mutation. Individuals may be forced to the limit of their variability by culture, and the effect may endure for a few generations when the inciting causes are removed, but it finally disappears. Thus when a species is acclimatized poleward, it shows a seasonal cycle of lessened length, or instead of annual it becomes biennial, this being a fair example of a direct useful and necessary adaptation and one of the clearest that can be found. A return to lower latitudes is followed by a reversion to the original habit, however, a process which may need two or more generations for its completion. The movement of a species toward the equator may result in a perennial habit, likewise of a temporary character.

While satisfactory proof of direct individual adaptation and its heritability is not at hand, and while many of the most highly specialized adaptations are known to have no causal connection with the external agency concerned, yet the possibilities are not to be ignored. The very vagueness of the subject is a challenge, and it is with the view to testing evidence and obtaining new facts, that the Desert Laboratory has established experimental cultures through a range of a vertical mile, from subtropical arid, to alpine humid climates, in which introductions and exchanges already made have been followed by marked somatic alterations. It remains to be seen whether any of these are adaptive, and whether the changes in question are irreversible or not. A decade will be necessary for any intelligent consideration of even the simpler phases of the subject.

It is now pertinent for us to inquire as to the possible stimulative or formative action which external forces may exert on the germ-plasm independently of the somatic or vegetative body, in the production of heritable alterations.

Experimentation upon the subject has, until recently, been carried on with the idea of producing somatic modifications, which might by repetition, or by profundity of alternation, be impressed on the germ-plasm and thus conveyed to successive generations. Recently, however, Tower has carried his work in the induction of new forms of beetles by climatic and other factors, to a point where he is satisfied that the effect of the external agent is directly upon the germ-plasm, with what remarkable results, as set forth in his notable contribution, you are already doubtless familiar.

My own investigations bearing upon this matter were successful in methods in which the action of the experimental agencies upon the germ-plasm was direct and capable of ready demonstration. As announced in 1905 it was found that the injection of various solutions into ovaries of *Raimannia* was followed by the production of seeds bearing qualities not exhibited by the parent, wholly irreversible, and fully transmissible in successive generations.

Encouraged by this success, a number of reagents were used in the following year with *Œnothera biennis,* a plant which had been under observation for some time, and

with which I was so familiar as to be able to recognize alternations readily. Of the various tests with this plant, one, which had been treated with a solution of zinc sulphate, gave seeds one of which produced a plant, known to my associates and myself as "F. 206," which differed so markedly from the parental form as to be recognizable by a novice. This form has been tested to the third generation, transmits all of its characteristics fully, and does not readily hybridize with the parent even when grown so closely in contact with it that the branches interlock.

With this additional success, next nine species in the genera *Opuntia, Cereus, Mentzelia, Argemone, Nicotiana, Eschscholtzia* and *Pentstemon,* which were growing naturally in the vicinity of the Desert Laboratory, were operated upon, using various solutions, inclusive of calcium nitrate, potassium iodide, zinc sulphate, and methyl-blue in various proportions from 1 in 250 to 1–50,000 parts of distilled water. Over a hundred thousand seeds were harvested from the treated ovaries and some were sowed in August, 1907. Most of the species in question develop slowly, and the seeds are difficult to germinate under control. I am not prepared, therefore, to make any definite announcement concerning the results, except to say that among the seedlings of *Cereus* are several which seem far from being typical.

The principal contribution to be made at the present time bears rather upon the mechanics of the action involved by this treatment. The original results were discussed with the assumption that the introduction of reagents into the ovary would be followed by action on the egg. In order to test this matter, solutions of methyl-blue were injected in the same manner as the other substances and examinations were made at various times from a few minutes to a day later, for the purpose of gaining some idea of the mechanical behavior of the fluids. The facts obtained from the great tree cactus, *Cereus giganteus,* will best serve as an illustration.

The ovaries of this plant are inferior and one-celled, the cavity having a capacity of about 2 c.c. The inner layer seems to function especially as a conductive tissue, and from it the concrescent funicular stalks arise, bearing the anatropous ovules to the number of several hundred, the whole offering exceptionally favorable conditions for treatment of the reproductive elements.

The large flowers open early in the morning and attract a variety of small bees and gnats, the former probably being instrumental in effecting pollination. If this is accomplished and the temperature rises to 80° F. the flower closes at the end of the day and falls off a day or two later. At lower temperatures, the flowers may reopen on a second or even a third day. The style is 5 or 6 cm. in length and the pollen tubes must traverse its length within twenty-four hours and probably accomplish it in much shorter time. It was, therefore, thought advisable to make injections between 10 A.M. and 4 P.M. of the day the flowers were open, or perhaps on the previous day.

Generally the needle of a charged syringe was thrust diagonally downward until the tip projected into the central cavity, and the reagent forced in by the pressure of the piston, as much as .5 c.c. being introduced in some instances. The use of this maximum amount would cause a visible enlargement of the ovary, but even in such cases the mucilaginous character of the tissues and the high turgidity would quickly close the wound when the needle was withdrawn. With lesser amounts and using the greatest care in manipulation, the operation was followed

by the death and casting away of a proportion of the treated ovaries which amounted to as much as 95 per cent. Similar fatalities resulted in other species and in some all methods of treatment were total failures, the ovaries being aborted within a day after being treated. The plants used during the last two years have been growing in a state of nature on the domain of the Desert Laboratory, and the ripening fruits were subject to the ravages of animals, with the result that the packages of seeds harvested represent but a small fraction of the total number of operations. To this destruction was added the inevitable loss of many of the seedlings. It is needless to say that, having used such a large share of effort upon plants, to which not the slightest imputation of "cultivation" could be attached, precautions of the most rigid sort will be used hereafter.

The coloring matter was injected in the several types of ovaries with various results, according to the anatomical features presented. It will be most profitable to continue the discussion by the citation of results with *Cereus*. In this species the coloring fluid, fairly representing one type of action of the several reagents employed, was absorbed almost entirely by the inner lining wall of the loculicidal cavity. The strong transpiration current quickly conveys the reagent upward to where the walls join and coalesce with the tissues at the base of the style. Here a mass of cells a centimeter in thickness was found to be so thoroughly impregnated with the solution as to be distinctly colored.

The funicular stalks had also taken up a large share and this had been conducted out along the concave flanks and through the conductive tissues as far as a mass of thin-walled cells in the outer part of the inner integument, being still separated from the antipodal cells by several protoplasts. The numerous glandular hairs on the funiculi were also deeply stained, probably by contact with the mass of liquid poured into the cavity. The cells surrounding the micropyle had taken up a noticeable amount, probably in the same manner.

Here then is a set of mechanical conditions under which the pollen tube carrying the generative nuclei can not reach an egg without passing through a deeply impregnated tissue at the base of the pistil, coming in contact with scores of charged cells, then after entering the cavity it touches and adheres to many of the impregnated trichomes of the funiculi, and, lastly, in reaching the egg, it must pass the endostomal cells, also heavily laden with the reagent. In the numerous anatomical examinations made, pollen tubes were found which had become stained before reaching the micropyle. In this species, therefore, any alteration in the normal transmission of hereditary characters might very well be ascribed to effects produced in the chromatin or plasma of generative nuclei of the pollen. In other instances the eggs, or rather the embryo-sac might be more easily acted upon by an injected reagent. It is to be said also that the *Cereus* structures might be affected in a different manner by other reagents, but in all cases the pollen tube would necessarily pass through tissues impregnated with the reagent.

The mechanism of the action of the reagents employed is not capable of ready analysis. It may be readily appreciated, however, that any withdrawal of water, or introduction of substance, would be followed by a disturbance of the balance existing among the various ions in the chromatin and plasma. The slightest disturbance of a protein, or even a modification of the relative rate at which various processes might be proceeding, would account for the profoundest changes in quali-

ties borne by mature plants produced. The modifications, of whatever character they may be, are probably beyond observation by cytological methods.

In addition to these direct effects it is within the range of possibility that the application of the reagents might set in motion the processes resulting in polyembryony, or parthenogenesis: it is to be noted, however, that the facts at hand do not suggest such a happening in the forms already obtained, but in the extension of these experiments to various types of reproduction these things must be taken into account.

While the method described is of interest as having possibilities for our intervention in the evolution of organisms, it becomes much more so if similar results may be expected in a state of nature.

Such a parallelism is to be found in the unusual intensities of the environic factors of light, temperature, moisture, etc., which have been used by Tower in the modifications of *Leptinotarsæ* which he has secured. Here, of course, the entire soma as well as the germ-plasm is subjected to the action of the inciting agent. The various distributional agencies by which seeds are constantly being carried far beyond the limits of the customary range of their various environmental conditions must result in the exposure of developing individuals and mature germ-plasm to unusual intensities which might well be responsible for such results. Thus, a stream takes its rise near the alpine plantation of the Desert Laboratory, and flows out on the desert a few miles away, and a mile lower down. Doubtless hundreds of thousands of seeds are carried to the lowlands each year. Some of these develop into individuals which carry out reproduction. This is usually done in the native habitat, at actual temperatures of the tissues not above 60° or 70° F. Down below, spore formation, reduction divisions and fertilization may ensue in temperatures 40° to 50° higher, a difference capable of being endured by the shoots of some plants, now being tested, and which might well cause irreversible developmental changes. Other factors of the environment may operate in a similar manner. Again, it is to be recalled that the actual formation, or intrusion of active substances in the ovarial tissues, may result from the stings of insects, the mycelia of parasitic fungi, the penetration by foreign pollen, or the egg or pollen may become subject to radium emanations or to X-rays or other forms of radiant energy. Still another possible action is to be accounted for: in hybridization the foreign pollen tubes, carrying the generative nuclei of the pollen parent, may encounter substances in the invaded pistil to which they are not usually subject, with the result that their capacity for transmission of parental characters may be altered, and qualities may thus appear in the progeny which are not active in either parent.

A hypothetical consideration of the known facts as presented by the many species in which mutation has been seen to occur seems to lead to the conclusion that the changes upon which discontinuity of inheritance rests, ensue previous to the reduction divisions in plants. The alterations which take place in my experiments however, follow disturbances not brought to bear upon the germ-plasm until after the second or third division following the reducing divisions and are perhaps separated from this act by a considerable period of time. It will be necessary, therefore, to alter our present conception of mutation, or to conclude that another form of alteration in heredity has been discovered. The former alternative seems possible and preferable. The forms induced may indeed have a cytological basis

similar to that which occurs in bud-sports or vegetative mutations, about which but little is known.

The opportunity does not permit an extended and thorough comparison between the results obtained by Tower with beetles and those by myself with plants, but the following points may be noted: The experimentally produced derivatives of beetles diverged from the parental type principally by one main character, with correlated variability in others. The induced forms in plants show many new qualities of fairly equal importance, so far as such things may be estimated, and these might be quite independent of each other. The new forms of beetles crossed readily and were readily swamped by the parental or other types. The new plants do not hybridize freely, if at all, even when grown with branches interlocking with the parental type. The few tests with the derivatives of *Raimannia* in New York and at the Desert Laboratory show it to be less capable of endurance to these climates, both of which are foreign to the parental type, than the parent. The derivatives of *Œnothera biennis* show equal endurance with the parent in the native habitat, and at the Desert Laboratory (2,700 ft.), but exceed it at the montane station (8,000 ft.). The changes produced in beetles are supposed to be a purely stimulative effect in the growth or maturation period of the egg, while those of plants may be due to similar action, or to the direct chemical disturbances produced by the reagents, during the period following the reducing division.

A restatement of the principal protheses of the work in hand upon the relation between environic and other factors and heredity will be profitable in closing. These may be briefly given as follows:

The forms and qualities exhibited by organisms represent the total effect of environment, but it can not be shown that this has been brought about by direct adaptation; many of the most highly specialized and useful structures bear only an indirect relation to the factors to which they bear a useful relation. Neither has it been demonstrated that an individual adjustment made by the soma is impressed upon the germ-plasm, and transmitted unchanged, although the inference is strong that this may be involved in rhythmical functions and perhaps in range of variability.

Various agencies experimentally applied in such manner as to affect the germ-plasm only have caused the origin of forms bearing fully transmissible qualities not presented by the parental type. The new characters have been found to be fully heritable, and the induced forms do not always hybridize with the older types.

The induction of such new forms in plants may be accomplished by reagents applied to the generative nuclei carried by the pollen-tube, and probably by action on the embryo-sac, in the period following reduction division. Mutations have been taken, on hypothetical grounds, to be based on changes occurring previous to these divisions.

The various agencies used in inducing new forms in this manner may have a stimulating effect, or may cause direct disturbances in the chemical balance of the substances in the chromatin and plasma. Similar action may result from unusual intensities of various environmental conditions, or to accidental intrusions on germplasm of many kinds. The alterations in question may well be beyond detection by cytological, or by any direct method of examination.

When the nature of the induced changes is once ascertained, the inductive agents might be applied in such manner as to guide the course of development and thus actually control the evolution of organ-

isms. In so doing, man, the conscious organism, would assume a dominating rôle in the world of organisms and create relations among living things not now existent.

D. T. MacDougal

TENDENCIES IN PATHOLOGY[1]

During the first half of the nineteenth century the science of pathological anatomy was created. Its rise was part of the development in the natural sciences which marked the beginnings of the intellectual expansion of the century, and its growth has continued unbroken up to the present day. Out of the science of anatomical pathology, which stands as the foundation subject of those disturbances in structure and function that constitute disease, there arose other sciences the pursuit of which has served to increase our understanding of the nature of disease. Chief among these are the sciences of general pathology, erected on the foundation laid by the discoveries in physiology, of pathological chemistry, which has grown out of the study by physiologists of the chemical changes connected with the different organic functions, and of the discovery by organic chemists of the nature and constitution of the compounds composing the organic skeleton and produced in the course of organic metabolism, and of bacteriology, that quickening subject, emerging Minerva-like out of the epochal investigations of spontaneous generation and the biology of microscopic plants and animals, which gave to medicine in a few pregnant years an era of discovery in the domain of the causation and the specific treatment of disease unparalleled in all medical history. The resultant of the discoveries in the newer fields of pathological knowledge constitutes the period of etiological pathology which, dating its beginnings from the middle of the last century, is to-day the dominant influence affecting medical thought. It is my wish to present to you briefly, as can only be done in the limits of a short address, certain of the tendencies in the study of pathology to be discovered at the present time.

[1] Address of the vice-president and chairman of Section K, Physiology and Experimental Medicine, American Association for the Advancement of Science, Chicago meeting, 1907.

To compass this broad field superficially even would demand more of your time than would be permissible on this occasion, so great are the activities to-day with which the subjects of general pathology, biological chemistry and bacteriology are being pursued. I have, therefore, adopted a very arbitrary course in the choice of subject-matter to bring before your attention and I have chosen to allude briefly to certain fields of inquiry in general pathology and to deal somewhat more fully with certain newer problems in bacteriology which are commanding at the moment the attention of the best laboratories, and I have left the fascinating field of biological chemistry to be dealt with by a far abler hand than mine.

The causation of disease is manifold, the reaction to abnormal influences is varied. The forces which divert the normal functions and bring disease into being are only in part external, at the time of their operation, to the body. All parasitic plants and animals, which disturb function or alter structure and produce disease, are essentially extrinsic agents of injury and have been introduced from without either during intrauterine life, of which there now exists objective proofs, or later in the period of post-fetal existence. The many causes of occupation diseases, so-called, in which we recognize the introduction into the body chiefly with the inspired air, but also by way of the digestive tract and possibly by way of other mucous surfaces and the skin, of injurious foreign particles, are at present only slightly understood and act not wholly,

probably, by increasing susceptibility to bacterial and allied infections, but often through direct chemical and physical malinfluences. A wide-spread interest in the improvement of the physical condition of the race, which has grown out of the social propaganda for bettering the condition of the poor, has produced in many quarters an active inquiry into the pathology of the occupation diseases from which much enlightenment may be confidently expected. But a complete knowledge of these external agencies, when it shall have been acquired, will probably fail to secure to us a full knowledge of the conditions which underlie all disease, since there is a class of diseases, some of very subtile nature, apparently, which result, in part at least, from errors and disturbances of balance in the development of the animal organism or in the correlation of its functions, of which we are at present beginning to appreciate the significance. The remarkable chain of events through which the function of one organ or set of tissues is determined and controlled by the secretion of another organ or set of tissues, as is displayed in the influence of excessive or diminished thyroid secretion on the state of nutrition of the body and functions of its important viscera, and of the metabolic products of fetal tissues upon the hypertrophy and growth and function of the mammary gland, can serve to indicate how dependent is progress in pathology upon knowledge of physiology and chemistry.

Physiology, pathological anatomy and experimental pathology having each contributed a share which the others could not have supplied, are promising to solve some of the problems of arterial hypertension and arterial degeneration in Bright's disease. The peculiar control which the adrenals exercise over the tone of the vascular system can be altered in two ways so as either to depress and relax the circulation or to exalt and increase its tension. The first, a result of ablation or tubercular disease, as in Addison's disease, is clearly of extrinsic origin; but the second, which is associated with certain changes in the gland of an adenomatous character, may not be so. It is this latter condition which has now been found a number of times in cases of sclerosis and atrophy of the kidneys associated with arterial hypertension and degeneration. Recalling the effects of adrenalin in increasing blood pressure, of the degenerations of the aorta produced in rabbits by injections of this drug, and the clinical phenomena in this class of cases of Bright's disease, it seems a natural step to associate the adrenal, the nephritic and arterial disease into one pathological complex. Whether the primary pathological condition is to be discovered in the kidneys and the histological alterations in the adrenals are consequent upon this, as the arterial degenerations are viewed as secondary to the changes in the adrenal, or the order is to be reversed, in which case the changes in the kidneys are to be conceived as following upon those in the arterial system, can only be surmised at the present time. But we may still view this tangible basis of observation and possibly of experiment with hope that in it somewhere may be found the key to the understanding of this complex and vastly important chapter of pathology.

Examples showing the importance of glandular integrity in maintaining a state of health and of disintegrity in producing diseases could, with our present knowledge, be multiplied so as to include most of the glandular organs. Many of these examples would be familiar to you. In some of the best understood examples the number of possible alterations in the glands is two, at least, and the pathological effects are different according as the secretion is

diminished or increased in quantity. A notable instance of this kind is found in the relation of the thyroid gland to myxœdema and to Basedow's disease. Still another instance, possibly, has just been mentioned in connection with the adrenal gland. But in the pancreas it seems not improbable that one and the same pathological effect is or can be produced by changes in the islands of Langerhans which make for diminution of secretion, or its increase, with, in the latter case, possibly, a qualitative change in its chemical composition. That is to say, atrophy and degeneration of the islands have now been found so many times in the pancreas of persons succumbing to diabetes mellitus that it would be accepted as a causal condition were it not for the occurrence in a certain number of severe and fatal clinical cases of diabetes of hypertrophy instead of atrophy of the islands. Analysis of the reported cases of diabetes in which the condition of the islands of Langerhans were carefully noted shows that it is in the diabetes of the young especially that the hypertrophied state of the islands is encountered, and the suggestion is a strong one and merits careful consideration whether the islands in these cases may not have been imperfectly developed and have yielded a secretion of such altered and abnormal quality as to have been the cause of the disturbance of the carbohydrate metabolism leading to the fatal diabetes. The conception is unusual, but it is not impossible and is in harmony with the facts so far collected. The mere fact that the pancreas and the islands of Langerhans as a whole are so rarely found even apparently normal in diabetics must be accepted as of great significance in respect to the point as to whether, after all, alterations in the islands are more than accidentally connected with the disease; for our histological methods are still so far from perfect that subtile cellular changes, now only suspected, will surely be discovered in the future.

In comparison with the great advances already achieved in the infectious diseases stands the relatively small progress made in the clearing up of the etiology of the more chronic diseases of the important viscera. The problems of the latter have, until now, except here and there, resisted all effort at their solution. What is chiefly lacking to a fresh and successful endeavor is a suitable and promising method of investigation, and we may well welcome, therefore, an experimental one which aims at a study of important tissues and organs transferred from one animal to another of the same or even of a different species, and the gradual ablation or sudden increase of important organs in order to establish the influences exerted by a new environment on certain organs, or transplanted organs on a new host, or the limit of destruction of tissues with normal and with pathological reactions, or the manner and degree of control capable of being exercised over a greatly augmented activity of different organs. The technical surgical operation involved in this kind of experimentation, on account of the necessity of maintaining unimpaired the circulation of the blood, is great but not impossible of achievement; and the final goal is so important, involving as it does the possibility of substituting sound for diseased organs in human beings, that no effort will or should be spared to reach it.

This method of experiment has, of course, nothing in common with the older one of transplanting minute portions of tissue from one animal to another. In spite of survival of these grafts, for a time, they have yielded very little of an active functioning nature to the new host. By the method of preservation of the circulation through the transplanted organs their

functions are maintained and, as a rule, in a perfect manner. Hence it now becomes possible to place sensitive and important viscera under new experimental conditions which may aim to resemble or to reproduce those believed to give rise to common pathological states in man, and to observe the effects over a long period of time. This method, in the hands of Carrel, its chief exponent, has already produced many new and highly important results relating to the blood-vessels, the kidneys, thyroid gland and other organs. It is a matter of no small theoretical and practical significance that arteries can be transplanted successfully from dog to cat, and *vice versa*, and from man to dog, and that keeping extirpated arteries under sterile conditions at refrigerator temperature for twenty or thirty days, or even longer, does not interfere with the results of transplantation; and the histological changes suffered by the transplanted vessels, whether in the same or different species, or made immediately after removal from the body or after several weeks in cold storage, are small in conformity with their perfect function as blood vessels.

The knowledge of the processes of inflammation has already been, and medical and surgical practise may hope to be, assisted by studies of the leucocytes from a physiologico-chemical point of view. The indispensable phagocytic function of the leucocytes—whether directed against micro-parasites or somatic cells worn out by physiological use or destroyed by pathological effects—is now so generally admitted that it seems trite merely to mention the property. But this *living* function of the leucocytes is supplemented by their demonstrated power to yield upon dissolution active proteolytic enzymes of considerable potency capable of attacking native and alien proteid. This enzymotic action can be and often is held in check by certain antienzymes contained normally in the plasma of the blood. Opie, to whom we owe the discovery of the antienzymotic power of the blood-serum, has shown, also, how greatly the issue of an inflammation is affected by the balance between the leucocytes and the serum, and how a purulent inflammation with solution of tissue is the product of collections of leucocytes whose enzymotic power is unrestrained by serum, and that the more superficial and less destructive sero-purulent exudations have the potential enzymotic activity of the leucocytes balanced and checked by the serum. It would appear not to be a long or particularly difficult step from the establishment of these conditions by experiments on animals to their application in human beings in whom the issue of inflammations may be promoted in the direction offering the best hope for the patient.

Until recently, all progress regarding tumors, excepting in their histological structure and place of origin, has been in respect to their surgical treatment. Improvement in operative methods by which local infection of the site of operation and general dissemination of tumor cells have been avoided, and the more complete removal of all tumor-infected tissue accomplished, have increased greatly the number of cures of malignant tumors. We are still ignorant of the cause of tumors, and there is no likelihood that the ignorance will soon be dispelled. But the study of transplantable tumors in mice and rats, chiefly, has already yielded many important facts concerning the biological conditions underlying tumor growth. These small animals, the domesticated races especially, are not infrequently the subject of spontaneous tumors which compass their death. The tumors are, therefore, malignant; in mice they are carcinomata, chiefly, springing from the mammary glands; in rats, sarcomata, chiefly, taking origin from

more diverse organs. Many, although not all, of the tumors are transplantable to new individuals of the same species and race, never to animals of another species, and less often to those of another race of a given species.

There is something extremely subtile in the conditions underlying successful transplantation within one race since it may be determined by such minor factors as environment and mere quality of food. A tumor used to growing in Danish white mice may fail utterly to grow in Berlin white mice, and one used to growing in Berlin mice and unable to grow in Norwegian mice, may lose its capacity to grow in Berlin mice transported to Christiania and kept there for a period before inoculation.

Artificial selection of fast-growing strains can modify a slowly-growing into a rapidly-growing tumor and increase the percentage of successful implantations. Once a high degree of power of growth is secured, it can be maintained. The method of selection for virulence is analogous to that for securing virulent strains of bacteria. But the analogy does not go much farther. It may be set down as a rule to which at present the exceptions are insignificant, that the more virulent a tumor is, the less it tends to produce secondary growths at a distance from the primary nodule. Tumors which grow slowly cause, not very infrequently, large secondary growths especially in the lungs; but those which grow rapidly never. Moreover, once the original graft of tumor has begun to grow vigorously, it is almost impossible to implant successfully a second graft. The metastases originate from tumor cells which have entered the circulation and been deposited in the capillaries of the lung. Now, highly virulent tumors, as is to be expected, invade the blood-vessels just as the less virulent tumors do, but in one case the cells at a distance develop into new tumors and in the other they lie dormant. If such a distinction exists in human beings, the subjects of malignant tumors, it has not been made out; but there are great variations in metastases in human cases of tumors, which have never been brought under any law governing tumor growth. My purpose, therefore, in speaking of this peculiar feature of tumor growth in mice is to bring out the fact of the existence of a form of immunity to tumor cells which may be restricted to one part of the body, or be general to the whole body. This immunity Ehrlich called *atrepsy* and he conceives it to be an expression of deprivation of the peculiar foodstuff required for tumor growth. In any body this peculiar nutriment is limited in quantity and hence if cells very highly avid with reference to it are growing actively in any part of the body they may draw all that is available to them and leave none for cells, even of the same nature, which are less avid or away from the focus of its accumulation. The immunities of species, possibly of races also, and the more subtile forms of immunity alluded to, Ehrlich thinks may be atreptic; and for this view there is more or less foundation in facts developed by experiment.

There remain many features of the experimental study of tumors of absorbing interest to the student of tumors in human beings, but they can not be discussed here without extending widely the length of this address. I may, perhaps, allude, before passing to another and quite different topic, to the interesting fact of the occurrence of grades of acquired active immunity in rats and mice that have been inoculated with tumor grafts which have grown but slightly, or which, having grown to a considerable size, later undergo complete absorption. Mice and rats which have recovered spontaneously from tumors

can be reinfected with new and more virulent grafts with difficulty or not at all; and recently the interesting fact has been discovered in Ehrlich's laboratory that in such partially immune mice a tumor which was originally adeno-carcinoma tends to revert to adenoma, or from a more heterogeneous to a more homogeneous structure. We see in this observation how fundamentally the state of the host reacts upon the nature of the tumor, just as in the case of increased virulence we saw how greatly the state of the tumor cells reacted on the host. And we can see the operation of this reciprocal interaction of tumor and host in the fundamentally important transformations in types of tumor, from cancer to sarcoma as shown by Ehrlich and Leo Loeb, and from sarcoma to adeno-carcinoma as observed by Jobling and myself, which are part of the recent gains accruing from the experimental study of tumors. Then I might add a word on the outlook for a more efficient therapeutics of tumors, now that tests can be made upon animals under conditions of scientific accuracy of experiment which will permit of the results being interpreted in a strict rather than in an empirical manner. Just as long as every therapeutic advance had to be made upon and with human beings the victims of tumors, just so long was it impossible to approach the subject in a truly scientific way, for just so long was it impossible to secure that control of experimental conditions that alone can make biological experiment accurate and advance logical and not a thing of chance.

I will now ask you to turn with me to a brief discussion of certain topics in bacteriology which are compelling attention at present. Bacteriology in relation to medicine suffered from a period of reaction to its many brilliant achievements and had for a time lingered somewhat in too familiar fields. But new problems, the direct outgrowth of the old acquisitions, are opening up and new lines of work are being laid down, some of which are of such gigantic importance to the larger interests of social hygiene, that many new forces are being brought into operation.

Perhaps the chief single compelling phenomenon is that of the microbe-carrier, who is everywhere coming to be regarded as a serious menace to the health of communities. He is not a new discovery, for, as regards diphtheria, he has been known for more than a decade. But now he has been found to disseminate typhoid fever, dysentery, plague, cholera, influenza, spinal meningitis, and in certain localities a host of protozoan diseases. Moreover, he is not, like the victim of tuberculosis, who is also a microbe-carrier, a sufferer from the disease which he disseminates; he is, as a rule, immune to the microbes in an actual sense and is usually ignorant of the sinister rôle which he plays in life. The period of time during which these pathogenic microbes can exist in the body is very variable, but may be great. In the case of typhoid fever forty-two years have been known to have elapsed since the attack, at the end of which time typhoid bacilli were still being eliminated with the dejecta. Plague bacilli have been present in the sputum seventy-six days after recovery from plague-pneumonia; influenza bacilli have been found in the sputum one year after an attack of influenza; and still other examples of long persistence of pathogenic microbes could be cited.

What is remarkable is that this persistence of pathogenic germs in the body can not be explained on the supposition that they are really outside the body, residing on mucous membranes, and hence not subject to the ordinary forces of destruction which operate in the blood and tissues. The typhoid bacillus increases chiefly in the gall bladder, which is indeed not within

the body, strictly speaking; but foci of development may exist in the kidney for many months, infecting the urinary bladder, and in bone and muscle, and they are strictly within the body. A distinction is not readily made between capacity of growth within and on the surface of the body, but evidence exists tending to show that certain tissues may develop immunity to pathogenic bacteria which usually injure them, and certain bacteria develop capacity to survive under conditions which are usually fatal to them.

It is just in this connection that we are learning that bacteriolysis and bactericidal effects do not necessarily go along with spontaneous recovery from and acquired immunity to bacterial diseases. These forces of immunity may be in active operation, so far as tests made outside the body with the blood indicate, at a time that the very bacteria from and against which they have developed may still be surviving in the body. Typhoid bacilli have been cultivated from the blood long after the subsidence of symptoms of typhoid fever and at a time when the titre of serum bacteriolysis was of prodigious height; pneumococci have been detected in the circulating blood of animals actively immunized to the pneumococcus; anthrax bacilli have been grown from the blood of immune and healthy sheep protected by anthrax vaccine, and living virulent tubercle bacilli of the human type have been obtained from the healthy lymphatic glands of calves inoculated with Bovo-vaccine and in consequence already immune to bovine tuberculosis. It is clear, therefore, that the immune state, so far as bacteria are concerned, can be no one-sided phenomenon in which the fact of all importance is the condition of the host, and that of small importance the condition of the invading bacterium. The phenomenon is, indeed, a reciprocal one and must take account of a high degree of capacity for adaptive changes on the part of the parasite as well as on the part of the host.

Many of the diseases due to protozoa show in a more striking way the same facts of mutual adaptation of parasite to host; and this power of survival of the parasites in the healthy body is what makes suppression of diseases transmitted from host to host by blood-sucking insects a matter of such difficult and uncertain achievement. The fact as regards malaria is well known, and this paradoxical condition of immunity and infection is established as true for trypanosomic, piroplasmic and spirillar diseases of man and animals. Koch has drawn attention, in a recent report, to the existence in the blood of healthy natives of the trypanosoma of sleeping-sickness from which the Glossina may readily become infected and made able to carry the disease. It is clear that the future studies in immunity will take into more direct account the changes in the infecting parasite produced by the immune state, and will seek means of their suppression which will leave the host uninjured and weaponed for a more successful resistance to invasion. In this field prediction is hazardous; but it need not excite great surprise if this desideratum should be accomplished through specific drugs suited to the purpose by subtile molecular adaptations, rather than by sera prepared by immunization with the parasites themselves.

The long discussion of the part played in natural and acquired immunity by the blood plasma or serum and the mobile phagocytes has now been settled so as to include both factors. The body fluids and the blood serum chiefly carry, as a result of immunization, dissolved substances which act at one time by neutralizing toxines that are themselves injurious and at another in sensitizing bacteria and other corpuscular bodies so that they may be en-

gulfed by phagocytes which destroy and render them innocuous. The discovery of the opsonins in the normal blood and their increase in states of induced immunity to bacterial and other infections, has added greatly to the clearing up of some of the complicated phenomena of the immune state. That many virulent bacteria—anthrax, chicken cholera, pyocyaneus, staphylococci and streptococci, pneumococci and others—exhibit negative chemotoxis, or are ingested far less by phagocytes than avirulent strains of the same microorganisms, is an old observation, and it is very enlightening to find, as Rosenow has, that virulent strains of pneumococci do not bind opsonin, while avirulent strains do, and extracts prepared from the virulent germs protect avirulent ones from phagocytosis to a greater degree than extracts of the avirulent pneumococci themselves. Cultivation outside the body as saprophytes of parasitic and non-phagocytable pneumococci and other bacteria, tends to alter their relation to the opsonins and to phagocytosis. From which it appears that virulence and negative chemotoxis depend upon certain chemical states of bacteria, determined by the conditions of their existence, and affecting the nature of their metabolic products, among which last are substances that are antagonistic to the functioning of the opsonins. Far as we still are from a clear and full conception of the distinction between virulence and avirulence in bacteria, we must nevertheless welcome this concrete fact as in itself a great gain.

The body infected with bacteria or other pathogenic microorganisms, although it survive the infection, may not be rendered more resistant; it may be rendered more susceptible to reinfection—that is, it may be sensitized to the infecting agent or its poisonous products. The state of hypersensibility, or anaphalaxis, the converse of that of immunity, has been studied with energy and profit during the last two years. Perhaps the best known example is the abnormal reaction developed when an animal infected with tubercle bacilli is injected with the products of the growth of the bacillus. Blood serum contains a substance, or substances, which under suitable conditions develop a reaction of this character. That the human organism reacts more vigorously to second and subsequent injections of horse serum than to the first injection is shown by the reports of many instances in which these stronger effects were noted after administering diphtheria antitoxin. It appears that the reaction of hypersensibility depends for its expression upon the existence in the sensitized body of a substance of the nature of an antibody comparable to, but doubtless differing widely from, the antibodies which are developed during the process of immunization proper to bacterial and other cells. In the case of hypersensitiveness to serum a second injection, in such small animals as the guinea-pig, may result fatally in a few minutes or after several hours; but should it not so result, the animals have been robbed of their sensitive or anaphalactic state and been rendered "immune" to horse serum in the usual sense, or antianaphalactic. These superficial facts suffice, in a way, to indicate that the antibodies governing the anaphalactic state differ from those governing the immune state, and it is, therefore, interesting to learn that they differ further in failing to give the Bordet-Gengou reaction of complement-deviation.

Studies in immunity pursued during the past several years have tended to show that it may be general to the body or more marked in one part than in another. Hence we have to distinguish a state of "general" and a state of "local" immunity; and it would appear, also, that the whole body may be sensitized or that sensitization may

be more limited in extent and restricted to certain tissues or locations. Wassermann succeeded in affecting the endothelial cells of the pleura by direct pleural inoculation of typhoid bacilli so as to increase their power to produce antibodies above that of the other tissues of the body, and Noguchi succeeded by localizing a tetanus infection in the subcutaneous tissue of the thigh to make it impossible for tetanus toxin to enter the body from that location while all other avenues of entry were left unaffected. And, as a parallel to these states of immunity, we see in the phenomenon of Arthus that the subcutaneous tissues of the rabbit can by repeated injections of horse serum be sensitized and thus made to react with a degree of vigor and inflammation which may cause their destruction, the rest of the body meanwhile showing no increase of sensitiveness.

The hypersensitiveness of the tubercular state would appear to be localized in tissues far removed from the seat of the infecting tubercle bacilli, and probably every part of the tuberculous organism is in a potential hypersensitive condition. In any case, the ophthalmo-reaction of Calmette and the cuti-reaction of v. Pirquet, both of which are yielding good service in the diagnosis of tuberculosis and taking the place of the more serious general reaction of hypersensitiveness following upon tuberculin injection, show that in the conjunctiva and the skin the cells are sensitized and react rapidly and in a characteristic manner to tuberculinization.

It will be clear to you that in following the diverse reactions of the body to foreign substances, among which parasitic microorganisms play in pathology the chief part, there is gradually being discovered a wide range of phenomena, some desirable and beneficial, some objectionable and injurious, which together constitute the effects of natural disease or of efforts to thwart and overcome it. It will become the particular quest of the immediate future to attempt the unraveling of those biological conditions which underlie one or the other of these, and to secure to the use of medical practise those effects which may be beneficial and to remove from it those which are injurious. Were there still time at hand, I should present to you certain newer facts in protective inoculation with bacteria and of serum therapy which are not without good augury for preventing certain infective diseases of man and animals, and of overcoming them by specific serum therapy once they have developed. And then I should try to interest you in the remarkable progress which has been made, and is being made almost daily, in the discoveries in specific chemical therapeutics which make the control of certain protozoan diseases—trypanosomiases and spirilloses especially—very hopeful for the future. I must, however, not detain you longer from the enjoyment of the interesting scientific program which has been prepared for this hour.

SIMON FLEXNER

CHARLES A. YOUNG

THE past five months have brought severe losses to astronomy in the deaths of five of its distinguished men: in Germany, Vogel, of Potsdam; in France, Loewy, of Paris, and Janssen, of Meudon; in this country, Asaph Hall; and now Charles A. Young, who died at Hanover, N. H., on January 3.

There is some consolation, however, in the fact that all of these men had reached advanced years,[1] and had in a measure rounded out their scientific careers, although the three first named were still in active service as directors of large observatories.

Charles Augustus Young was born on

[1] Average age, 75 years.

December 15, 1834, at Hanover, where his grandfather and father successively occupied the chair of natural philosophy in Dartmouth College during the period from 1810 to 1858. He entered college early and graduated with distinction in 1853 as bachelor of arts. During his student days he assisted his father in astronomical observations and accompanied him in 1853 on a trip to Europe to purchase instruments for the Shattuck Observatory, then in course of erection. For two years after graduation he taught the classics at Phillips Academy, pursuing at the same time theological studies at the Andover Seminary. In 1857 he went to Hudson, Ohio, as professor of mathematics and natural philosophy at Western Reserve. During several summer vacations he assisted in the governmental survey of the great lakes. Responding to the call of patriotism in 1862, he was for four months Captain of Company B in the 85th Regiment of Ohio Volunteers, which was largely recruited from students.

In 1866 he returned to Dartmouth as professor of natural philosophy and astronomy, thus continuing the family tradition.

The next few years were stirring times in astrophysical research. The spectroscope was just beginning to be applied in the study of celestial objects, with results of surprising interest. The eclipse of 1868 was made memorable by the discovery by Lockyer and Janssen of the method of observing the solar prominences. In spite of heavy duties as teacher, Young applied himself assiduously to solar research. He observed the eclipse of 1869 at Burlington, Iowa, establishing the fact of the gaseous nature and truly solar origin of the corona. Employing what was for those days a very powerful spectroscope, he quite accurately located the position of the green corona line, which was thereafter known as No. 1,474 on Kirchhoff's map of the solar spectrum. It was not until the eclipse of 1898 that the position of the line was more correctly located, by Professor W. W. Campbell observing in India, and was shown not to be represented by a dark Fraunhofer line. At the eclipse of 1869 Young also looked for, but failed to detect, the reversal of the dark lines at the moment of internal tangency of moon and sun. But he realized his expectations at the Spanish eclipse of the next year, when he discovered the "flash spectrum." He describes it in these words: "The moment the sun is hidden, through the whole length of the spectrum, in the red, the green, the violet, the bright lines flash out by hundreds and thousands, almost startlingly; as suddenly as stars from a bursting rocket head, and as evanescent, for the whole thing is over within two or three seconds."[2] This phenomenon was subsequently observed visually in a more or less satisfactory way by different astronomers at other eclipses, but it was not photographically recorded until 1896, when it was caught by Mr. W. Shackleton at Nova Zembla with the prismatic camera.

In the early seventies Professor Young gave much attention to the spectrum of the chromosphere and to the prominences. Many of his delineations of these have become classics from their reproduction in various works and text-books. He devised an improved form of solar spectroscope which served his purpose very effectively. His assiduity was rewarded by his observation of a number of rather unusual solar phenomena: such as the highest recorded prominences, extraordinary velocities indicated by distorted lines, up to 320 miles per second; violent solar agitation associated with magnetic storms. He was the first to attempt to photograph the prominences and attained a partial success (1870). With the wet plates then neces-

[2] *The Sun*, p. 82.

sarily employed an exposure of four minutes was necessary with the use of the dark blue line of hydrogen (H_γ). This degree of insensitiveness of the films made it undesirable to spend time on such photographs.

In 1876 he made the first use of a grating spectroscope in astronomical work, and measured the rate of rotation of the sun by the displacement of the lines at the east and west limbs.

Professor Young successfully observed the transit of Venus of 1874 at Peking, and went to Russia for the eclipse of 1887, but was prevented from work by clouds. He had clear skies at the eclipse of 1878 at Denver, and in 1900 at Wadesboro, N. C. He also particularly studied the chromospheric lines, and made a list of 190 which he had noted with the spectroscope attached to the Dartmouth nine-inch telescope. The advantage of a high elevation becoming evident, he made an expedition in the summer of 1872 to Wyoming, where with the apparatus taken from Hanover, at an elevation of 8,000 feet, he added another hundred lines to his list. The subsequent increase in these lines, aside from those found in eclipse photographs, has been chiefly due to his own observations at Princeton.

In 1877 he accepted a call to Princeton, where much larger instrumental facilities were offered to him, with less confining teaching duties. He gave, however, much time to the organization and equipment of the students' observatory, making it then probably the best in this country. A powerful spectroscope was provided for the 23-inch equatorial of the Halsted Observatory, and with this he made important observations of the chromosphere and sunspots. He discovered in 1883 that the absorption spectrum of the sunspot umbra may be resolved into "countless and contiguous" dark lines, a difficult observation later amply confirmed by others. With the Halsted refractor he also made micrometric observations of planets and satellites. He carried out an extensive program of observations of the transit of Venus in 1882 at Princeton.

His admirable work "The Sun," of the International Scientific Series, appeared in 1881 and presented in a clear and interesting manner the known facts and theories of solar physics. It includes many of his own interpretations of difficult points and is the authoritative work on the subject. It is characteristic of his modesty that many of his own discoveries (such as that of the reversing layer) are there given without mention of his own name, and would only be recognized as such by those familiar with the circumstances, who could read between the lines, or by those who happened to consult the index. Several editions of this work appeared, and it was translated into several foreign languages. The last, thoroughly revised, edition was published in 1895.

His "General Astronomy," the first of his important series of text-books which have been used by more than a hundred thousand students, was issued in 1888. It represents much more than a mere text for students, and has been widely used as a work of reference. The "Elements of Astronomy" and "Lessons in Astronomy," adapted for more elementary students, were published a little later. The "Manual of Astronomy," comprising most of what was in the General Astronomy, but with more illustrations and with the inclusion of the latest data, was issued in 1902.

The fundamental idea in Professor Young's text-books, popular articles and lectures, was that statements should be accurate as far as they go. He was no special pleader, and in his public utterances always fairly stated both sides of dis-

puted matters, and he avoided controversy in a manner exemplary to younger men. His public lectures were not popular by reason of any eloquence of delivery or of rhetorical skill, but because of their clearness, simplicity and convincing quality of accuracy. As a teacher he was particularly successful; having himself a splendid grasp of the fundamentals of mathematics and physics, he presented his subject logically, with emphasis on the essentials; and his humor enlivened the class room. It is doubtful if any teacher in this country has enlarged the intellectual horizon of a greater number of undergraduates than has he, in his culture courses in astronomy. "Twinkle" will never be forgotten by any of his students.

Professor Young's eminent services in research and education received recognition in numerous academic degrees, membership in and awards from various learned societies.

He had suffered from Bright's disease for a number of years; but by good care had kept himself fairly comfortable. The loss of his wife seven years ago, after forty-four years of a particularly happy married life, came as a crushing blow to him; and to his sorrow was lately added the death, after a year of distressing illness, of his widowed daughter, who made her home with him.

The retirement from his position at Princeton in the summer of 1905 was made the occasion of a grateful recognition by his colleagues, and the appreciation shown by his friends at that time must have been a source of much gratification to him. He then returned to Hanover, where he lived quietly, until he succumbed to a brief attack of pneumonia on January 3. Two days later he was gathered to his fathers in the old cemetery close to the house where he was born.

EDWIN B. FROST

YERKES OBSERVATORY,
January 14, 1908

SCIENTIFIC BOOKS

Experimental Zoology. By THOMAS HUNT MORGAN, Professor of Experimental Zoology in Columbia University. New York, The Macmillan Company. 1907.

In a recent number of SCIENCE there appeared an extensive review of this book, which, in the opinion of the writer, does scant justice to an important and valuable work. It is with the thought, therefore, of calling attention to some of the many valuable features of the book that the following supplementary review is written.

Although experimental zoology is one of the youngest of the sciences it has grown so rapidly that it is practically impossible for one not working in this field to keep pace with its development. Until recently there was but one journal devoted to this subject and much of the literature pertaining to it is scattered through publications which are more or less inaccessible. From time to time there is needed in every science, and especially in one not well organized, some general work, which will not only summarize results and bring many scattered observations under one point of view, but which will also awaken interest in the subject and point out the direction of needed research.

Such a book is this of Morgan's—a book which is not only full of information, but which is also illuminating and stimulating. The writer of this notice has made this book the basis of a course of reading for graduate students in zoology with the most satisfactory results. The book discusses in a very concise and direct manner a great range of experimental work in zoology, much of which, it is safe to assume, is relatively unfamiliar to many zoologists. Although these discussions are usually brief, they go straight to the heart of the matter under consideration, and they generally exhibit a critical insight and a breadth of judgment which indicate a thorough acquaintance with the phenomena in question. By the variety and extent of his own experimental work Morgan is probably better fitted than any other man in America to write a general work on experimental zoology.

The book begins with a well-balanced estimate of the relative value of observational and experimental work; it maintains that experiment is the only method by which zoology may be placed upon the same footing with chemistry and physics; it points out the uses and abuses of scientific hypotheses and the necessity of verifying these by experiment; and it concludes that the goal of experimental work is, in the words of Loeb, the control of natural phenomena.

The scope of experimental zoology is so great that it can not be treated as a whole within a volume of ordinary size. The author has therefore omitted from consideration two important fields of study, viz., experimental embryology and the experimental study of regeneration, both of which he has dealt with in other books. The present volume is mainly devoted to those aspects of experimental zoology which have not hitherto received adequate treatment in book form.

The principal topics discussed fall under the following six headings: (1) Experimental Study of Evolution, (2) Experimental Study of Growth, (3) Experimental Studies in Grafting, (4) Experimental Studies of the Influence of the Environment on the Life-cycle, (5) Experimental Studies of the Determination of Sex, (6) Experimental Study of the Secondary Sexual Characters.

Under the first heading are included a large number of topics such as the influence of external conditions in causing changes in the structure of animals, the inherited effects of changes due to environment, the inheritance of acquired characters, experimental hybridizing, the behavior of the germ cells in cross fertilization, inbreeding, the influence of selection, and finally the theory of evolution. These topics are dealt with unequally, the first in particular being very brief, while the last is from its nature rather more speculative than experimental in character. There is everywhere, however, a wealth of reference to works on these topics and many valuable and stimulating suggestions. With the chapters on experimental hybridizing I think it may be said that Morgan first strikes his gait in this book. This subject is treated at much length and in a thorough and admirable manner.

The section of the book on experimental studies on evolution forms rather more than half of the whole work. The remaining sections deal with subjects of a more special character. Under the experimental study of growth, the chapters on the external factors that influence growth, and on growth and regeneration are especially worthy of favorable mention. A single chapter is devoted to experimental studies on grafting, but this chapter is one of the best in the book, and it shows at once the author's intimate and extensive acquaintance with this subject. In the chapters on the experimental studies of the influence of the environment on the life-cycle Morgan has brought together results which are probably less familiar to the average zoologist than are any other topics dealt with in the book. The literature references in these chapters indicate through what a range of publications, many of them relatively inaccessible and but little known, the author has labored in preparing this summary.

The final sections on the determination of sex and on secondary sexual characters deal with some of the most interesting subjects in zoology. The various hypotheses are considered fairly and judicially and the author's own views are set forth in a form which is clear, if not always convincing, and which is sure to stimulate research. And after all this last is perhaps the greatest service which any book can render. In a work which covers so wide a field it is natural that minor faults should occur, but it would be unjust to suppose that it does not also have great merits. Morgan has placed all zoologists under obligation because of this book; it has been received with the highest commendations abroad, and it is a work of which American zoologists may well be proud.

EDWIN G. CONKLIN

The Soil-preferences of Certain Alpine and Subalpine Plants. By M. L. FERNALD. Contr. from the Gray Herbarium. Rhodora, September, 1907. 44 pp.

It is refreshing to find, in this study of Fernald, a distinct departure from the hack-

neyed gathering-up of superficial observations on "plant associations," without any mention of the probable, in many cases abundantly obvious, causes of the geographical grouping of plants. Ecological studies, as often made savor strongly of the "gedankenlose Heusammler" habit animadverted upon by Schleiden over half a century ago, and were apparently only temporarily stopped by Darwin's great work. The soil-conditions accompanying the occurrence of certain plant groupings are usually so superficially set forth that nothing but the old classification into hydrophytes, mesophytes and xerophytes is attempted; in conformity with a hypothesis based upon the arbitrary assumption that moisture is the only controlling factor of plant growth. Adding to this hypothesis the factor of soil-texture, and basing thereon the entire work of soil classification, Whitney and the Bureau of Soils of the United States have built up a one-sided theory, which is in flagrant contradiction to facts observable by any one not under the official afflatus of that head center. Some years ago R. M. Harper, in his studies of the plant geography of the southern Coastal Plain, entered upon the right track so far as observations in the field are concerned; but Fernald has added to the field observations a closer discussion of the exact physico-chemical factors which condition plant distribution, such as I have urged for fifty years past.

In defining his investigations as relating to certain "alpine" plants, Fernald really blurs the nature and importance of his work. Alps are usually rocky and have predominantly *sedentary* soils, that is, soils overlying the rocks from which they have been formed by weathering, without having received admixtures of the decomposition-products of other rocks. Such admixtures may, nevertheless, easily occur locally. Moreover, the fact is that the flora of mountains is often largely paludal on account of their "young" geological surface features, and therefore commonly include wet meadows, ponds and lakelets alongside of cliffs and rocky slopes. The frequent washing-down of the decomposition-products of various rocks on the higher slopes to those lower down, has made the word "alpine flora" a designation referring mainly to temperature-conditions. Fernald himself, however, at once recognizes the distribution of the "subalpine" flora to be almost identical with that of a large portion of the lowlands.

Fernald presents (pp. 158 to 164) lists of 258 plants belonging to the territories of New England and Canada, tabulated so as to show their occurrence, either preferably or exclusively, upon rocks considered respectively as potassic,[1] calcareous and magnesian.

These tables show, in three columns, the plants belonging to soils formed from (supposedly) potassic, calcareous and magnesian rocks, and exhibit the very striking contrasts, as well as some coincidences, in the floras inhabiting the three classes of rocks.

Among the most striking of these is the often-observed poverty of the vegetation on soils derived from exclusively or chiefly magnesian rocks, such as serpentine and talc schist; to which may be added dolomite, which, though consisting more than half of lime carbonate, shows everywhere a more or less depauperated flora, especially when compared with adjacent areas of non-magnesian limestones. Fernald shows how, on the north slope of Mt. Albert, a serpentinous plateau in Gaspé county, by the partial admixture of calcareous and potassic rocks an immediate increase of species and a more luxuriant development take place. A very few plants only are known to prefer purely magnesian soils, everywhere. Among these, Fernald mentions specially, *Cerastium arvense,* whose ash contains the unusual proportion of 19.8 per cent. of MgO.

Fernald promises, by analyses of the ashes of a number of these plants (as well as, it is to be hoped, of corresponding soils) to establish definitely the relations between their plant-food requirements and their rock habitats. As regards the soils, it is evidently of high importance that the analyses should be made by such methods as will show their *permanent* character, and not merely the accidental present

[1] Whether the granites, gneisses and mica schists assumed by Fernald as producing soils rich in potash really do so, is somewhat questionable, and should be verified by analysis.

condition; since the distribution of native plants is a matter of secular or millennial, and not merely of existing conditions. The interpretation of these analyses will require no mere routine consideration of percentages, but must be correlated with the physical composition; inasmuch as a light sandy oil requires much less lime to support a calciphile flora than a heavy clay;[2] and the same is more or less true of other ingredients. It should not be forgotten, however, that quite a large number of plants have long ago been shown to be practically indifferent to the absence or presence of lime.

Again, the paludal or peaty nature of the ground or locality requires consideration. The mere *presence* of a certain proportion of lime may be wholly ineffective in bringing about a calciphile flora if humic acids present produce an acid condition of the soil mass. On the other hand, if a calcareous weathering-product is exposed to continuous leaching, as may easily happen on the summits of hills bearing abundant vegetation, the lime carbonate may be almost wholly leached out, and islands of calcifuge plants will then be found in calciphile territory. The calcareous washings, on the contrary, will impregnate the lower ground, which is always more calcareous than the higher slopes; and so a calciphile flora may, and very commonly does, occur where no obvious source of lime exists in the uplands.

Fernald rightly considers the hornblendic rocks as sources of calcareous soils; yet in the Hawaiian islands the black lavas, which weather into spongy iron ores used as soils, are almost fully leached of the lime that forms so large a proportion of both pyroxene and hornblende, by the abundant rains of the tropics; while the almost identical basalts on the Pacific coast produce calcareous soils, with a uniformly calciphile flora, on account of the deficient rainfall.

It is thus obvious that not only the original soil-forming rocks, but also the climatic conditions and the "lay of the land" must be considered in forecasting the plant-geography of any region. The failure to do this and the physiologically erroneous definition of calcareous soils as "soils that effervesce with acids," has brought about the confusion which appears in the works of Schimper, Contejean and others, as to the causes of plant distribution.

[2] See "Soils," etc., pp. 494–497, 367 ff.

Fernald's paper is provided with copious references to sources of information in relation to the occurrence of rocks and plants, as vouchers for his conclusions. On the other hand, his references to cognate work done in Europe as well as in this country, are somewhat scanty, being probably left for the final publication of his results.

His present conclusions are succinctly set forth in the following quotations from p. 170 of the paper:

After comparing the floras of three areas located not far apart and under identical conditions of exposure and precipitation, he says:

> Precipitation and exposure are, then, of only minor importance in determining the localized distribution of our alpine plants.
>
> In attempting to account for the peculiarities of plant distribution, much stress has of late been laid upon the degree of fineness or coarseness of soils, and their water content. But to those intimate with the occurrence of our alpine plants these factors, again, seem of secondary importance. For instance, *Cystopteris montana* on Mt. Albert grows in equal abundance on the firm and steep amphibolite cliffs and in the deep, fine and (water-) saturated alluvium of mountain streams. *Selaginella selaginoides*, abundant in the wet, mossy bogs of Bonaventure and Gaspé counties, Quebec, is quite as much at home in the well-drained alpine meadows, or in the crevices of either wet or dry rocks; in the latter situation becoming stiffer and more stocky than in deep shade or moisture. *Zygadenus chloranthus* is apparently indifferent whether it is in the crevices of sunbaked rock, on cold cliffs, in river alluvium or on wet bogs. Similarly, many other members of the flora characteristic of the areas classed as group 2 (calciphile) grow in wet or dry, fine or coarse soils.
>
> The distinctive plants of groups 1 and 3 (potassic and magnesian) likewise show a remarkable indifference to the coarseness or fineness, the dryness or saturation of their supporting soils . . . seem equally at home in crevices of sun-baked or

spray-showered rock, on sandy plains, in well-drained alpine meadows and in saturated sphagnum bogs. . . . we are hardly justified in depending upon these (physical) factors to explain the distribution indicated in the preceding tabulation.

In other words, Fernald's observations show that in accordance with the ancient experience of mankind (although contrary to the officially promulgated doctrine), certain chemical soil-conditions are not only equally as potent as, but sometimes prepotent over, even extreme physical conditions, notably in the case of lime; so that without the accompanying study of chemical soil-composition, mere physical analysis gives no definite clew to soil-values, adaptations and peculiarities. It is to be ardently hoped that the broader method of ecological investigation, as exemplified by Fernald's work, will be more generally applied, and so render such work both theoretically and practically more fruitful than it has been in the past. For what is true of wild plants is of necessity true for cultivated ones also.

E. W. HILGARD

BERKELEY, CALIF.,
Oct. 10, 1907

SOCIETIES AND ACADEMIES

THE OHIO ACADEMY OF SCIENCE

THE seventeenth annual meeting of the academy was held at Miami University, Oxford, O., on November 28, 29 and 30, the president of the society, Mr. Charles Dury, of Cincinnati, presiding. On Thursday evening an informal reception took place in Hepburn Hall, where accommodations for members of the academy were generously provided by the university authorities. The sessions on Friday and Saturday were held in Brice Hall.

The address of the president on "Zoological Reminiscences of the Cincinnati 'Zoo,'" occurred at 1:30 P.M. Friday, while in the evening at 7:30 Professor G. W. Hoke discussed "The Nearer East—A Study in Social Geography." Other papers of interest were those by Professor Bruce Fink on "The Status of American Lichenology," Professor S. R. Williams, "A Peculiar Circulatory Modification of *Necturus maculosus,*" E. F. McCampbell, "Report on a New Pathogenic Pirosome" (presented by Professor Herbert Osborn in the absence of the speaker).

The following is the complete program:

"A Study of the Origin and Growth of the Egg in *Syncoryne mirabilis,*" by Mary D. Mackenzie.

"A Better Method of Preparing Herbarium Specimens," by W. A. Kellerman.

"Compensatory Growth in *Podarke obscura,*" by Sergius Morgulis.

"Note on the Development of the Skull in Clupea," by Edward L. Rice.

"Factors determining Cave Habitation as illustrated by the Cave Isopod and its Nearest Outdoor Ally," by A. M. Banta.

"*Symbiotes duryi* n. sp., a New Endomychid from Ohio," by L. B. Walton.

"Notes on the Early Development of Enteropnuesta," by B. M. Davis.

"The Discomycetes of Oxford and Vicinity," by Freda M. Bachman.

"*Wolffia brasilensis* in Ohio," by Robert F. Griggs.

"The Psychology of Speaking," a Scientific Analysis of the Art of Speaking," by John S. Royer.

"The Flora of Cranberry Island, Buckeye Lake," by W. A. Kellerman.

"Reaction of Amphibian Embryos to Tactile Stimuli," by G. E. Coghill.

"The Epibranchial Placodes of Ameiurus," by F. L. Landacre.

"Periodicity of Spirogyra," by W. F. Copeland.

"The Dispersal and Planting of Seeds by Nature's Methods," by W. L. Lazenby.

"The Male Reproductive Organs of *Cimbex americanus* Leach," by H. H. Severin and H. C. Severin.

"A Peculiar Circulatory Modification in *Necturus maculosus,*" by S. R. Williams.

"A Migration of *Anosia plexippus* in Ohio," by Herbert Osborn.

"The Variability of Zygospores in *Spirogyra quadrata* formed by Scalariform and by Lateral Conjugation, and its bearing on the Theory of Amphimixis," by L. B. Walton.

"Some Observations concerning the Effects of Freezing on Insect Larvæ," by J. S. Hine.

"The Status of American Lichenology," by Bruce Fink.

"Stains for Embryonic Skeletons," by E. L. Rice.

"A Note on the Occurrence of *Typhlopsylla octactenus* in Ohio," by Herbert Osborn.

"The Development of the Swimming Movement in Amphibian Embryos," by G. E. Coghill.

"Natural History Notes from Hamilton County, Ohio," by Charles Dury.

"Some Rare and Unnamed Mushrooms found in the Cuyahoga Valley" (lantern slides), by G. D. Smith.

"Report on a New Pathogenic Pirosome," by E. F. McCampbell.

"The Marine Biological Survey of the San Diego [California] Region," by B. M. Davis.

"The Development of a Kelp," by R. F. Griggs.

"Regeneration and Inheritance," by Sergius Morgulis.

"The Gold Fish—*Carassius auratus* L.—and its Color," by L. W. Sauer.

"A New Experiment in Ionization," by F. J. Hillig.

"The Lateral Line Organs of Ameiurus," by F. L. Landacre.

"Annual Report on the Ohio State Herbarium for 1907," by W. A. Kellerman and Freda Detmers.

"Notes on Philomycus," by V. Sterki.

"Observations on the Life History and Adaptation of a New Semi-aquatic Aphid, *Aphis aquaticus*," by C. J. Jackson.

"Variation in Temperature and Light Intensity when Growing Plants under Cloth of Different Colors," by W. A. Kellerman and G. W. Hood.

"One Hundred Species of Mushrooms of the Cuyahoga Valley" (lantern slides), by G. D. Smith.

"Some Homologies between the Mouth Parts and Walking Appendages in the Hexapoda," by L. B. Walton.

"Ancient Finger Lakes in Ohio," by G. D. Hubbard.

"A Deposit of Glass Sand at Toboso, Ohio" (lantern slides), by Frank Carney.

"The Origin of Spring Valley Gorge near Granville, Ohio" (lantern slides), by Earl R. Scheffel.

"Extra-morainic Drift in the Baraboo Area, Wisconsin" (lantern slides), by Kirtly F. Mather.

Stratigraphical Studies in Mary Ann Township, Licking County, Ohio:

"Distribution of Formations" (lantern slides), by Frank Carney.

"A Phase of the Sharon" (lantern slides), by William C. Morse.

"Two Notable Landslides," by Geo. D. Hubbard.

"Pleistocene Deposits at Clay Lick, Ohio" (lantern slides), by Kirtly F. Mather.

"A Group of Eskers South of Dayton, Ohio" (lantern slides), by Earl R. Scheffel.

"An Overflow Channel of a Glacial Lake in Yates County, N. Y." (lantern slides), by Frank Carney.

"High Level Terraces in Southeast Ohio," by G. H. Hubbard.

"An Ecological Classification of the Vegetation of Cedar Point," by O. E. Jennings.

The committee on the state natural history survey was enlarged and continued. A committee consisting of the incoming president, secretary and treasurer was appointed to confer with the Indiana Academy of Science relative to the holding of joint meetings periodically by the two societies. It seemed to be the opinion of members of the society that such meetings could profitably be held at intervals of approximately three years in some locality near the border line of the two states.

The society adopted a resolution expressing its sense of loss in the deaths of two members during the past year, Albert Taylor and William Curtis Whitney.

After adopting resolutions expressing the appreciation of the society for the courtesies extended by the faculty and others at Miami University and furthermore thanking Mr. Emerson McMillin, of New York, for his continued interest in the welfare of the academy, the society adjourned. The following officers were elected for the coming year:

President—Professor Frank Carney, Granville, Ohio.

Vice-presidents—Professor J. H. Schaffner, Columbus, Ohio, and Professor F. C. Waite, Cleveland, Ohio.

Secretary—Professor L. B. Walton, Gambier, Ohio.

Treasurer—Professor J. S. Hine, Columbus, Ohio.

Executive Committee—(*ex-officio*) Professor Frank Carney, Granville; Professor L. B. Walton, Gambier; Professor J. S. Hine, Columbus; (elective) Professor Bruce Fink, Oxford; Professor Lynds Jones, Oberlin.

Board of Trustees—Mr. Charles Dury, Cincinnati, Ohio (in place of retiring trustee).

Publication Committee—Professor E. L. Rice (in place of retiring member).

L. B. Walton,
Secretary

THE NEW YORK ACADEMY OF SCIENCES—SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY

At a meeting of the section held on Monday, October 21, at the American Museum of Natural History, three papers were read.

The Selective Reflection Characteristic of Salts of Carbonic and Other Oxygen Acids: L. B. MORSE.

I. *The Selective Reflection of Carbonates as a Function of the Atomic Weight of the Base.*—Polished plane surfaces of (Mg, Ca, Fe, Mn, Zn, Sr, Ba and Pb) CO_3 were prepared and the ratio of the reflected to the incident radiation was measured at short wave-length intervals between 4 μ and 15 μ. The following are the principal conclusions reached:

1. The reflection curves for all the carbonates examined show between 4 μ and 15 μ three, and only three, bands of abnormal reflection. Abnormal reflection interpreted means a free resonance period of the molecule.

2. The bands fall into three separate and definite spectral regions, which are distinct from the regions where the salts of other acids, so far as known, show reflection maxima.

3. With few exceptions, an increase in the atomic weight of the base causes a shift of all three reflection maxima toward long waves by an amount roughly proportional to the change in atomic weight of the base.

This is shown for the first reflection band by curve *A*, Fig. 1, in which the atomic weights of the bases are plotted as ordinates, and the wave-lengths of the "first" reflection maxima as abscissæ.

II. *The Rôle Played by Oxygen in the Selective Reflection of Carbonates, Nitrates, Sulphates and Silicates.*—Combining with the data on carbonates the scattered observations of other observers on nitrates, sulphates and silicates, the tentative hypothesis has been made that the oxygen atom is the one chiefly responsible for the marked reflection observed.

The wave-lengths of the first reflection bands in $CaCO_3$, KNO_3,[1] $CaSO_4$ and $MgSiO_3$[2] are plotted as abscissæ, curve *b*, Fig. 1, and as ordinates the weights of the acid-forming elements combined with O_3 ($C=12$, $N=14$, $\frac{2}{3}S=24$, and $Si=28$).

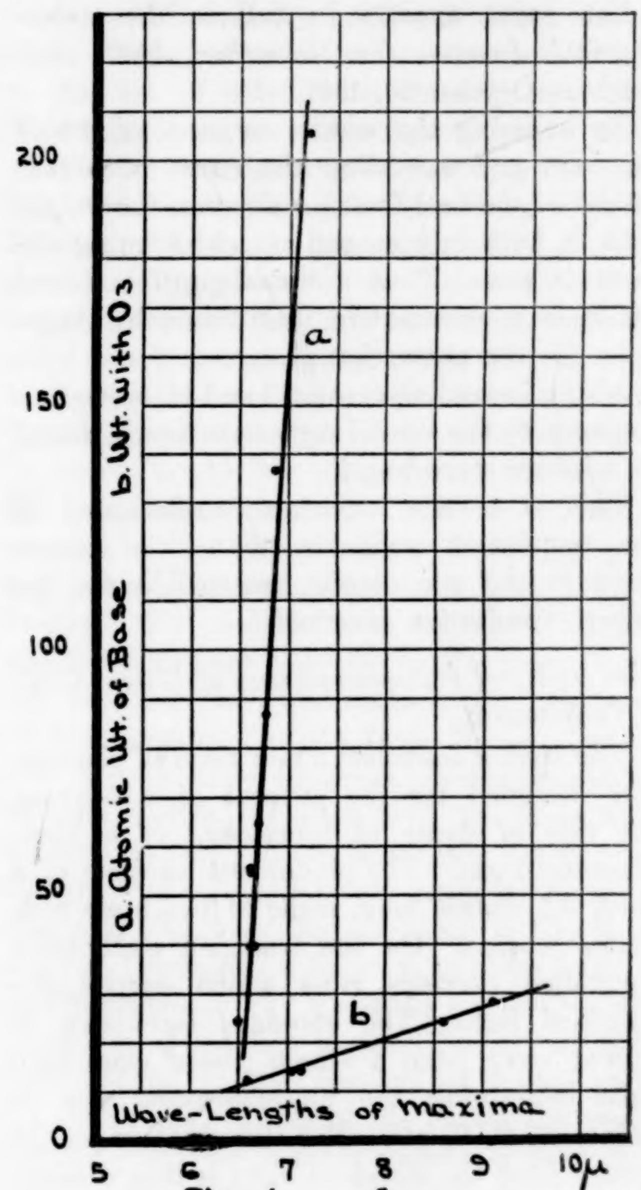

Fig 1.

The lines drawn show clearly that a small increase in the weight of the acid-forming element produces a much greater displacement of the reflection band than does the same increase in the weight of the base, and this is in full agreement with the chemist's view of the relative strength of the bands existing between the *acid-forming element* and oxygen, and that between the *base* and oxygen.

The results suggest a new and far-reaching method by which it may some time be possible

[1] Two values are plotted for KNO_3 corresponding to the results obtained by two independent observers, Pfund and Coblentz.

[2] If a correction be applied to correct for Mg being lighter than Ca, this would bring the $MgSiO_3$ point even nearer the line drawn.

to express the dynamical relations existing between the separate atoms of a molecule, and thus the present conception of chemical bonds and linkages be given a broader significance.

The paper appears in full in the *Astrophysical Journal* for November, 1907. Addendum, October 30, 1907.

By reducing the results to zero weight of the base and extending the curve *b* to zero weight of the acid-forming element, the weight with O_3 both in base and as acid-forming element is zero. Thus a wave-length is found which is approximately that found by Ångström for the absorption of ozone.

Also a second absorption band in ozone corresponds to the second carbonate bands, found at a longer wave-length.

This is a very important confirmation of the assumption made viz., that, "the oxygen atom is the one chiefly responsible for the selective reflection observed."

The Decay of Phosphorescence of Gases: C. C. Trowbridge.

The author described a new form of photometer designed for the purpose of measuring the rate of decay of luminosity of a phosphorescent gas. The photometer consists of a track 3.5 meters long, made of two brass rods under tension. On the track an electrically controlled carriage runs which carries the standard light. The standard light can be moved away from a screen placed close to a tube containing the phosphorescent gas to points *A, B, C,* etc. The illumination on the screen from the standard light is thus directly compared with the luminosity of the gas, and comparisons are made at *A, B, C,* etc., as the gas fades. Seven readings can be made within ten seconds, giving a variation of from 1/2 to 1/25 the original intensity of the phosphorescent gas. The entire apparatus is operated electrically, time being registered on a chromograph.

By means of this photometer the law of the rate of decay of phosphorescence for gases has been found. In this case, for air at about 0.1 millimeter gas pressure, the expression is the same as that for the decay of phosphorescent solids, or

$$I = \frac{1}{(a + bt)^2}.$$

Plotting the reciprocal of the square roots of the intensities, in the case of one decay of luminous gas, with the corresponding times gives a perfectly straight line. An application of the law to the grading of the light of a body of phosphorescent gas as great in size as a meteor train shows that the light of the self-luminous meteor train can be explained on the assumption that it is a gas phosphorescence, although the train may be visible for thirty minutes. A certain brightening of the sky around the radiant point at the time of meteor showers which has been called the "auroral light" is also explained by the application of the same law. In the latter case it is evident that the feeble phosphorescing of many trains has combined to give a pale glow in the regions of the heavens through which the shower was taking place.

Some Temperature Measurements taken in the Steel Works with the Wanner, Féry and Le Chatelier Pyrometers: W. Campbell.

The author briefly described the instruments used, methods of standardization and application. The temperature readings obtained at the blast furnace were: Metal, 1375° to 1250° C.; slag, 1425° to 1375°. At the Bessemer converter, 1600° C., very hot blow; 1500° C. cool. Average blows 1550° C. The steel was cast at 1500° to 1460° C. At the Open Hearth the furnace temperatures varied from 1550° to 1705° C., the surface of the bath being 1705°. The steel was cast at 1540° to 1460° C. The temperatures of the gas producers varied greatly, one set averaging 650° C., another over 850° C. The most important readings were taken at the Rail Mill, on the finishing temperatures of steel rails. The readings with the Féry pyrometer varied from 1000° to 1070° C., whilst the Wanner averaged 1100° C.

At this meeting Professor D. W. Hering was nominated for vice-president and chairman of the section for 1908, and Professor W. Campbell for secretary.

At a meeting of the section held on Monday, November 18, three papers were presented.

Waves and Rays in Physics: Doris W. Hering.

The author pointed out the extent to which waves or rays have dominated in explaining the transmission of a disturbance through space, as many as seven different kinds of waves having been employed, and no less than twenty-one different kinds of rays. The most fruitful generalization was Fourier's analysis of wave motion in his "Théorie Analytique de la Chaleur"; the boldest contention was that of Fresnel in advocating transverse vibration to produce waves of light; the most recent and comprehensive generalization was Maxwell's electromagnetic theory of light. The recent great increase in the number and variety of "rays" has been attended by a great deal of charlatanism.

Tool Steel-making in Styria: R. F. Böhler.

Reviewed the development of Styrian steel trade from prehistoric and Roman times up to our own days. The paper emphasized a number of special features characteristic of Styrian steel which are so many reasons for its superiority: (1) Crucibles used but once, (2) extreme purity of ores, (3) extensive or exclusive use of charcoal, (4) special skill of workmen in hammer- and heat-treatment.

The works, founded 1446, are now decidedly up-to-date; have pyrometric control; electric melting and hardening furnaces; latest physical testing methods, metallography.

As a consequence extensive use of Styrian steel in the five continents, for tools, rifles, shells, etc., also field guns, motor cars. Hundreds of tons of high-speed steel shipped to the United States yearly.

Electrolysis of Silico-Fluoride Solutions: Dr. E. F. Kern.

The author first of all took up the preparation of the electrolytes, current density, etc., and showed numerous specimens including metallic surfaces of lead, nickel, iron, copper and silver deposited from silico-fluoride and other solutions for comparison. The method on a commercial scale for the purification and desilverization of lead is employed at Trail, B. C., and elsewhere.

William Campbell,
Secretary

Columbia University

DISCUSSION AND CORRESPONDENCE

A BRITTLE-STAR NEW TO THE WOODS HOLE REGION

Through the kindness of Mr. George M. Gray, the well-known collector of the Marine Biological Laboratory at Woods Hole, Mass., I am enabled to make an interesting addition to the list of echinoderms known from the Woods Hole region. A single specimen of a brittle-star was dug out of the mud between Ram and Devil's Foot Islands in August, 1907. It was taken to the laboratory alive and in good condition, but in the course of a few hours it shed its disk, leaving only the mouth parts attached to the arms. The disk, as well as the remainder of the animal, was preserved in formalin and the specimen was subsequently sent to me by Mr. Gray for identification. There is little doubt that it is an excellent example of *Amphioplus abdita* (Verrill), a species previously known only from Long Island Sound. It is recorded from near New Haven and from Thimble Islands, by Professor Verrill, and there are specimens in the Museum of Comparative Zoology from Noank, Conn. The Woods Hole specimen measures about 6.5 mm. across the disk, and the arms are between 80 and 90 mm. in length. It differs from Professor Verrill's very complete description, and also from the specimens in the Museum of Comparative Zoology, in three important particulars: (1) the arms are noticeably shorter in proportion to the diameter of the disk; (2) the scales of the disc are coarser and the six primary plates at the center are conspicuous; (3) the color is uniformly gray instead of variegated or yellowish-brown. It is greatly to be hoped that further search will bring to light more specimens at Woods Hole, of this mud-loving species, for it will be interesting to see whether the above-mentioned peculiarities are at all constant. It would also be of great interest to investigate the cause, method and consequence of disk-shedding, a habit known to be frequent in the family to which *Amphioplus* belongs, but concerning which we know almost nothing.

Hubert Lyman Clark

Museum of Comparative Zoology,
November 14, 1907

SPECIAL ARTICLES

THE FOUR INSEPARABLE FACTORS OF EVOLUTION. THEORY OF THEIR DISTINCT AND COMBINED ACTION IN THE TRANSFORMATION OF THE TITANOTHERES, AN EXTINCT FAMILY OF HOOFED ANIMALS IN THE ORDER PERISSODACTYLA [1]

In a recent address entitled "Evolution as it appears to the Paleontologist" [2] I promised a fuller exposition of the law of the four inseparable factors.

During the past six years a very careful analysis of the modes and factors of evolution has been made in connection with my exhaustive study of the Perissodactyl family of Titanotheres, with the following result: all the processes and modes of evolution should be grouped under the *primary* processes of (1) heredity, (2) ontogeny, (3) environment, (4) selection. In this grouping heredity includes solely changes in the germ plasm. Ontogeny includes the somatic expression of heredity, somatic modification and adaptation, as well as the somatic environment of the germ plasm. Environment includes all nature external to the organism. Selection represents all competition, survival or elimination of individuals representing the combined product of heredity, ontogeny and environment. Variation is not included here because it is a *secondary* process.

A survey of the history of evolution theory shows successive waves of opinion or schools holding to the chief or more or less *separate* influence of these processes as factors; for example, environment (Buffon), ontogeny (Lamarck), selection (Darwin), heredity (the modern school). There is a very large element both of truth and of error in the tenets of each of these schools, because while the influence of each of these factors is undeniable, the exclusive influence of either of these factors is never found in nature, and can exist only in the mind of the observer.

The actual state of living nature is that of the *inseparable* and continuous action of these several factors as expressed in the following most fundamental biological law:

The life and evolution of organisms continuously center around the processes which we term heredity, ontogeny, environment, and selection; these have been inseparable and interacting from the beginning; a change introduced or initiated through any one of these factors causes a change in all.

Representing these processes respectively by the capital letters H, O, E, S, life and evolution may be represented by the formula:

$$H \times O \times E \times S.$$

This formula roughly expresses the intimate nexus which exists between all these processes, a nexus which is quite consistent with the fact that each has also its separate part in life and in evolution. The multiplication sign, $\times$, is to be interpreted in the active and passive sense of *influencing and influenced by.* As examples of what is meant by this formula we may cite such principles as the following: (1) that heredity is conditioned by ontogeny and environment; (2) that selection operates on the product of heredity, ontogeny and environment; (3) that ontogeny initiates many changes which are subsequently taken up by heredity; (4) that of the four processes involved in life and evolution heredity is by far the most conservative and stable, among other reasons because it is embodied in a form of matter (germ-plasm) least subject to changing external influences; that ontogeny, on the other hand, is the most unstable.

In contrast to the graphic representations of the original extreme hypothesis of Weismann, in which heredity is represented as a continuous current more or less isolated from ontogeny and environment there may be presented the following diagram.

This diagram brings out the real cause of the difficulties which arise, as illustrated below

[1] Abstract of paper read before the American Society of Zoologists, New Haven, Conn., December 26–28, 1907. This address was first delivered to Columbia students, November 3, 1905, and has been held two years for further consideration, before publication.

[2] Osborn, Henry Fairfield, "Evolution as it appears to the Paleontologist," SCIENCE, N. S., Vol. XXVI., No. 674, No. 29, 1907, pp. 744–749. Address before Seventh International Congress of Zoology, Section of Paleozoology, Boston, August, 1907.

(1-4), when we attempt to determine at what point in the chain of processes a new character is set in motion, in course of investigation of the initiation or origin of new characters.

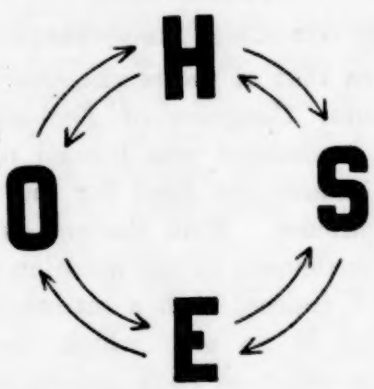

Diagram illustrating the reciprocal influences of heredity, ontogeny, environment and selection. Arrows *across* the circle would represent these relations still more completely.

1. For example, as concerns *heredity*, consider the slow "mutations of Waagen" or the rapid "mutations of De Vries." According to an *internal* theory the point of origin would be expressed by a formula presenting the theory that mutations originate in heredity, namely:

$$H^1 O E S.$$

The experiments of MacDougal[3] and others in the New York Botanical Gardens showing that mutations are sometimes set in motion *externally* or through environment, would be represented by the formula:

$$H^2 O E^1 S.$$

2. Similarly, as concerns *ontogeny*, the theory of the phenomena of "organic or coincident selection" might be represented by the following successive formulæ:

$H O^1 E S$ = first or ontogenetic phase.

$H^2 O^1 E S$ = second phase, or phase of coincidence of heredity with ontogeny.

$H^2 O^1 E S^3$ = third phase, in which coincident ontogenetic adaptations and hereditary predispositions are selected.

Here again the originating cause may be the environment, in which case the formula should be written E^1, O^2, H^3, S^4. This is a further example of the constant operation of the "inseparable law."

3. The initial influence of *environment* in the origin of new characters (or revival of ancestral characters) has been well illustrated recently in the interesting experiments of Beebe[4] in the New York Zoological Park, in which the eggs of the same mother bird (*Scardafella*, the scaly dove) were subjected to two extremes of environment, all other factors being excluded, with two types of plumage resulting. Here the formula is clearly:

$$H O^2 E^1 S.$$

4. Finally, as concerns *selection*, while it is admitted that this factor originates nothing, there are periods of intense struggle for existence when selection takes most active part in the perpetuation of certain characters and elimination of others and is thus indirectly initiative.

We are forced to the conclusion that all hypotheses which treat of these four processes as separable in a state of nature are unsound; that all methods of investigation which proceed on such assumption are unsound. At the same time investigation and experiment may proceed to test two working hypotheses: *First, that while inseparable from the others, each process may in certain conditions become an initiative or leading factor; second, that in complex organisms one factor may be initiative in one group of characters while another factor may at the same time be initiative in another group of characters, the inseparable action bringing about a continuously harmonious result.*

APPLICATION OF THIS LAW TO THE TITANOTHERES.—The hypothesis of the simultaneous operation of several factors on different groups of characters could only suggest itself to a paleontologist working upon a very complex organism in which an almost countless number of characters is simultaneously evolving. The analysis of these processes as applied to

[3] MacDougal, "Heredity and the Origin of Species," *The Monist*, January, 1906. Rept. Dept. Bot. Research (extract from fifth Year Book, Carnegie Inst., pp. 119-135), p. 129.

[4] Beebe, C. William, "Geographic Variation in Birds, with Especial Reference to the Effects of Humidity," *Zoologica*, N. Y. Zool. Soc., Sept. 25, 1907, pp. 1-41.

the evolution of the titanotheres is based on thousands of measurements, of the skull and teeth especially, and on comparisons of an exceptionally rich series of specimens in successive geological levels. So far as they have gone they appear to confirm the hypotheses of the separate and combined operation of the four factors on different classes of characters. A few illustrations only may be given of results which will be set forth very fully in the monograph.

1. Heredity appears to dominate the origin of new cuspules in the teeth because they arise in the form of rectigradations, that is, with a slow, definite, and continuous origin, in an adaptive direction and controlled by ancestral affinity. That is, the *same* results appear independently in descendants of the *same* ancestors.

2. Ontogeny rather than heredity appears to be in part an initial factor in fashioning the form of the cranium. We can not regard this as controlled by ancestral affinity, because descendants of the *same* ancestors give rise to *different* results, that is, to extremely divergent broad-skulled and extremely long-skulled forms.

3. Environment, besides its indirect action through heredity and ontogeny, seems to act broadly upon such change as the continuous increase of size, which independently favors the increase in size of the members of four series of titanotheres in contrast to a fifth which is dwarfed in size.

4. Selection (by our definition not an initiative factor), while generally operating on the whole sum of characters or the sum total of the organism, seems in this case to have operated especially on fluctuations in skull breadth or skull length respectively, in relation to the browsing or grazing habit; these congenital fluctuations being connected with ontogeny and organic selection.

The above is a very brief statement of the results of analysis of the evolution processes in general, and of the application of these processes to titanothere evolution in particular. It applies especially to the origin of new characters, with the clear appreciation of the end result that all such characters, or the potentiality of giving rise to them, finally become *germinal* or hereditary.

Henry Fairfield Osborn

QUOTATIONS

THE CONCILIUM BIBLIOGRAPHICUM

We learn that at the recent meeting of the International Congress of Zoology held in Boston a committee was formed to raise an adequate endowment fund for the Concilium Bibliographicum. With the one exception of the final settlement of the question of nomenclature—if, indeed, such a settlement be possible—there is no step which the congress could have taken of such importance as this for zoologists in general, nor are there many which could have anything like its economic importance. The literature of zoology is at once the most extensive and the least accessible of all those of the natural sciences. It is estimated that the number of persons engaged in zoological investigations of one kind or another amounts to several thousands, while—to ignore altogether works published independently—there are more than 3,000 periodicals, written in over 20 different languages, which may contain matter of interest for the naturalist. Unfortunately, the difficulty of the situation is made greater by the refusal of most of these journals to limit the matter they publish to any one branch of zoology and also by the importance which claims of "priority" may give to articles that have appeared in the most obscure periodicals. Moreover, it is precisely those papers which, directly or indirectly, are of the greatest economic importance (whether to economic entomology, to the study of fisheries, or to parasitology) that are the hardest for the working zoologist to hear of and to obtain.

The Concilium Bibliographicum was founded in 1896 under the auspices of the International Congress of Zoology. Its offices are situated in Zurich and its staff of librarians and clerks is under the direction of Dr. H. H. Field. The work of the Concilium is to examine as many of the periodicals of the world as are accessible to it, to make abstracts of their contents, and to publish the results of its labors in the form of a card catalogue

of zoological literature. Each article is read by a zoologist who determines for what classes of workers the paper is of interest and prepares a brief résumé, noting any new species or genera described. In order to indicate the contents of the articles, the topics met with have been arranged in the form of a comprehensive classification and then numbered, so that each paper is assigned by a numerical symbol to the divisions with which it deals. The reference to each paper is printed on a card and bears the appropriate numbers to designate one of the topics treated in the publication. Where the reviewer finds various matters treated in one paper several different editions of the cards are printed, differing only from one another in the classificatory symbol employed. Thus a given work may be found to contain an account of the occurrence of a white badger in a given country, together with considerations on albinism in general. The paper would emerge from the hands of the reviewer with a symbol for each of these aspects. The indication 11.57 would mean that the paper in question dealt with albinism, and the card would accordingly be sent to subscribers interested in that subject; the symbol 9.74 Meles would mean that the card must go to all subscribers interested in the badger; and a third symbol would designate the country or district in which the animal was found. The naturalist interested in the absence of pigment in animals (albinism) subscribes for that portion of the catalogue which deals with his subject, and receives every two months the new citations of papers on albinism. Some of these may refer to observations made near at hand; but much will relate to foreign publications and might remain unknown save for the agency of the Concilium. The whole series of cards may be subscribed for by an institution, which thus secures a bibliography of zoology since 1896, the value of which, in saving time and ensuring acquaintance with the literature of any branch of the subject, is incalculable. Since it is issued on cards the catalogue is not only always up to date, but has all the references on a given topic together at one point.

Unfortunately, the actual services rendered by the Concilium, great though they have been, have fallen somewhat short of its program. This, however, is entirely due to the limitation of its resources. The organizers of the institute are satisfied that the experimental period has proved beyond question that the program can be fully realized if they be provided with the necessary means. It is to find these means that the committee we have mentioned has been formed. Their success is greatly to be desired, and that, as we have shown, in wider interests than those of zoology alone.—From the London *Times*.

A LETTER RELATING TO THE BIOGRAPHY OF LAMARCK

PROFESSOR JOUBIN, chairman of the Lamarck Memorial Committee, has just sent the American members of this committee a copy of a letter dealing with the biography of Lamarck, written by his son nearly half a century ago. Its materials are timely and I append a translation.

LETTER OF GILLAUME DE LAMARCK, SON OF THE GREAT NATURALIST, WRITTEN JUNE 11, 1865, TO HIS SON EUGÈNE DE LAMARCK, THEN LIEUTENANT ON BOARD THE SLOOP OF WAR "SURPRISE"

My Dear Son:

I have read with pleasure the few lines you sent me taken from a work of which I have never heard. *Histoire naturelle des professeurs du Jardin des Plantes*—this is indeed a singular title. One would have thought it the history of some class or other of animals; one of the most important works of my father is entitled: *Histoire des Animaux sans Vertèbres;* but "The Natural History of the Professors"—that seems to me a little strong.

Be this as it may, the eulogy does exist and it is merited. Moreover, this is not the first that I see. Nevertheless, the name of my father has remained in obscurity. I always feel provoked when I see the statues erected to Georges Cuvier, to de Jussieu, to Géoffroy Saint-Hilaire, or when I see the names of these scientists given to the streets which surround the Jardin des Plantes, when I see the busts of the professors in the galleries of the Natural History Museum, all with the exception of that of my father. But what can one do about it? It does not merely suffice to have the reputation, to have the scientific

knowledge, to be a genius, a thing which is very much rarer, but one must still be able to make one's value felt, to push one's self, to extend one's influence and above all things to flatter the great. That talent my father did not have.

In his time there were two men around whom were grouped all of those who aspired to make a name in science. They were Laplace and Cuvier.

Around Laplace were grouped all the geometricians and the physicists; around Cuvier the naturalists. And there was no saving grace to any one outside of these two coteries. It goes without saying that my father belonged to neither. He remained in his corner, making no visits, and receiving only occasional strangers, and the several students whom he installed in his work room and to whom he opened all of his collections. So no one spoke of him; his most remarkable works passed unnoticed. His ideas, which were new, bold, and too advanced for the time when he wrote, contributed, also, perhaps, to keep him in obscurity, if they did not, indeed, give people an opportunity for ridiculing him. I am willing to believe that it will not always be like this.

I have spoken of a reason for the discredit which was cast upon the works of my father; but this was not the only one. There was still another, and even more grave. It was the disgrace brought upon him by the all-powerful master who then ruled.

My father loved to penetrate untrodden fields, he avoided paths too clearly marked out; for him accident was a word empty of meaning; he believed that in nature all things were subject to laws as certain as mathematics; but to discover them one must observe the facts, make comparisons and admit only the explanation which was in concord with all the facts observed. The study of meteorology attracted his attention; he gave himself up to it with the more zeal, since it was a science still in its infancy, a science as he loved them. For a long time people had, indeed, carried out meteorological observations, but these observations no one had been willing to study or to draw from them deductions. My father wished to undertake this task.

There was then in the Ministry of the Interior an intelligent man, a distinguished scientist, Chaptal. M. Chaptal approved of the project of my father. He created for him an office in his ministry and furnished him with correspondents at different points throughout the country. My father wished to keep the public in touch with the progress which he would have made in the study undertaken by him, and to this end published a meteorological year-book in which he had the unfortunate idea of including both memoirs purely scientific and probabilities of the weather to come. This was intended to help along the sale of the work, but it furnished also a weapon for his critics. The astronomers of the Bureau of Longitude, furious to see a naturalist exploit a field which they believed belonged to them, hastened to avail themselves of this weapon; they transformed "probabilities" into "predictions," and upon this ground they made a great outcry. A member of the Institute to play the part of a Mathieu Lansberg! . . . They petitioned the emperor to cause such a scandal to be stopped. The emperor was a member of the Institute and this was not one of the titles of which he was least proud. In a public reception he apostrophized my father sharply on this subject and concluded by telling him that botany should be kept within its proper bounds. ("La botanique! A la bonne heure!") From that time the ministry deprived my father of his office and his correspondents and stopped the publication of the meteorological year-book. Thus it was that the reprimand of a sovereign before whom the entire world trembled succeeded in placing outside of the scientific pale an old man who petitioned no one, who lived retired, and who sought for nothing but the advancement of human knowledge!

Nevertheless, of what nature was this old man? Let us examine his career.

Child, and the last born, of a numerous family, he had been sent to the Jesuits at Amiens and destined to the priesthood. There was no other alternative for noble families. He had to be either priest or soldier. All of the elder ones were soldiers. So my father had to be priest. But it was not his vocation, and when he learned of the death of his father his first words were: "Such being the case, I shall not be a priest." He left the college and returned to his mother, who, not knowing what to do, yielded finally to his wishes and sent him, at the age of fifteen, to the army in Germany, commanded by Marshal de Broglie, to serve as a volunteer. He took with him a letter of recommendation to Colonel de Lastic, who received it with lively dissatisfaction, seeing only an embarrassment in having so young an apprentice to the trade of war. It was then on the eve of a battle of which I have forgotten the unpronounceable name. We were defeated through the fault of the Prince de Soubise, who failed to effect a junction with the marshal, as had been explicitly arranged in a council of war. The French army had to retire. My father

finding himself in command of a company of grenadiers—on account of the death of all of the officers and by virtue of his nobility, fought on in a brilliant action which will be too long to describe, and which earned for him the epaulets of sub-lieutenant on the field of battle. It was a good commencement for his military career; but peace was made soon afterwards and he had to return to France and begin garrison life. I will not continue; he was forced to sell his grade of lieutenant of infantry on account of a tumor which appeared on his neck.

It was then that he made a complete change in his career. No, I am mistaken: he first remained for a while with his mother at the paternal manor; this was a time of forced inactivity, which one would be glad to drop out of his life. But finally his mother died. He had to sell the estate of Bazantin. There remained to my father only a very meager income. He had to live, he had to make a career. My father went to Paris. He first studied medicine, then abandoned this for botany. This science pleased him, he had a taste for it, he gave himself up to it ardently. One day, as he was walking with other students in the botanical school of the Jardin des Plantes, he laid a wager that he could identify whatever plant was presented him, any one at all, provided they informed him in advance the principal characters which distinguished the fruit (végétaux). He asked, in order to prepare himself, a certain delay, which was granted him, and on the day fixed, in this same school of botany, in the midst of a numerous assembly, the trial took place, succeeded, and the wager was won. Such was the origin of the Flore Française. The means devised by my father consisted in the successive elimination of two opposed characters, which is the method of dichotomy employed to-day in all classifications of natural history. The success of the Flore Française was truly prodigious. It was printed at the expense of the king and opened to my father the gates of the Academy of Sciences.

I pass without comment several other works which he published on botany and which put the seal to his reputation as a botanist. To come to those of his works to which he himself attached the greatest value.

The museum was about to be reorganized. Several new chairs were added to those already existing. The mammals, birds, fishes and reptiles were given to Géoffroy Saint-Hilaire and all of the mass of lower animals were given to my father. No one, Linné excepted, had then thrown light into the chaos formed by these beings. My father undertook to disentangle them. He established at once the great distinction which divides the animal kingdom into two classes, vertebrate and invertebrate. And the latter class, which up to then had been nearly despised, became of such importance, when my father had brought into it the order which remains there at present, that it has been judged too large to be in the charge of a single professor, and it has been made to-day the object of two different chairs.

It is in his zoological works that the genius of my father had its full scope. To appreciate them properly one should have a knowledge which I do not possess. I can only cite the *Philosophie Zoologique* and the *Histoire des Animaux sans Vertèbres*. These are the two monuments which will appeal to posterity from the coldness of his contemporaries.

Will this appeal ever be heard? I doubt it. Nothing is more difficult to uproot than a preconceived opinion. Men are like sheep; they follow blindly their leader without inquiring the road where he is leading them. They judge rarely by themselves, and find it most convenient to adopt without examination the judgments which time has given them.

It seems that this ingratitude of mankind has been the penalty inflicted upon my father for his neglect of the fulfilment of his duties as head of the family.

I can not deny, indeed, that his conduct in this regard is not reproachless. Undoubtedly it is ideal to devote one's self to science without the slightest regard to worldly ambition or to fortune, but this is the very condition which the interests of the family will not suffer.

My father was three times married—from the first marriage he had six children, from the second two and from the third none.

* * * * * * * *

The conclusion of the letter contains the history of the five sons of the naturalist, only one married, the author of this letter. Of Lamarck's three daughters, the eldest, Rosalie, was his devoted secretary in the days of his blindness.

BASHFORD DEAN,
Treasurer of the American Branch of the Lamarck Memorial Committee
COLUMBIA UNIVERSITY,
NEW YORK

EDWARD GARDINER GARDINER

EDWARD GARDINER GARDINER was the son of Edward Gardiner, of Boston, and of Sophia

Harrison Mifflin, of Philadelphia. On his father's side he traced his descent from George Gardiner, who settled in Aquidneck, Rhode Island (the site of the present town of Narragansett), in 1635. On both sides his ancestors had distinguished themselves by services to their respective communities and to their common country. He was born in New York City July 29, 1854, and died in Boston November 4, 1907. He was married April 6, 1895, to Miss Jane Greene Hooper, who, with two children, a boy and girl, survives him.

He was educated at the Boston Latin School and intended, as a matter of course, to enter Harvard, but a trouble with his eyes cut him off for several years from all studies. During this time he made the acquaintance of Professor Alpheus Hyatt, and his association with this distinguished naturalist awoke in him a love of science destined to be lifelong. He assisted Professor Hyatt sorting scientific material in the Museum of Natural History of Boston, and with him made repeated cruises for collection of material as far north as Labrador. His interest in biology and his warm affection for Professor Hyatt led him to pursue his studies at the Massachusetts Institute of Technology, at first as a special student, which was all his eyes made possible. In 1882 he graduated with the degree of Ph.B. and went abroad for two years to carry on his scientific studies. In 1884 he received the degree of Ph.D. from the University of Leipzig, the subject of his thesis being "Beiträge zur Kenntniss des Epitrichiums und der Bildung des Vogelschnabels," published separately and also in *Archiv für Mikroskopische Anatomie,* Vol. XXIV., 1885. Leuckart, for whom he often expressed great admiration, was his principal teacher in Leipzig, but he also attended the lectures of Rauber, Zirkel, Credner, Schenk, Marshall, Fraisse and Chun.

On his return from Leipzig, he entered the laboratory of Professor W. T. Sedgwick in the Massachusetts Institute of Technology and was welcomed as a well-trained zoologist. After a year as graduate student in Professor Sedgwick's laboratory, he was appointed successively assistant and instructor, in which capacities he served from 1885 to 1892. Professor Sedgwick writes that "Gardiner was always a devoted friend of the laboratory and left us because teaching had become irksome to him and interfered greatly with the original work which he hoped and expected to do at Woods Hole."

In 1888 Dr. Gardiner was elected a member of the original board of trustees of the Marine Biological Laboratory, which included also William G. Farlow, Alpheus Hyatt, Susan Minns, Charles S. Minot, William T. Sedgwick and Samuel Wells. Dr. Gardiner, who had consented to enter the board to fill a temporary vacancy, soon withdrew, but it was for a year only, and in 1890 he was again elected a member of the board and served continuously to the time of his death, when he was the only member of the original board remaining on it. He shared in the work of the first session of the laboratory, 1888, and was instructor in 1889, 1890 and 1891. He served as clerk of the corporation from 1895 to 1902 and again from 1906 to the time of his death. He also acted as secretary of the board of trustees from 1896 to 1902 and was again elected to the same office only three months before death deprived the board of his valuable and efficient services.

It is impossible in a brief sketch to even mention the numerous services rendered by Dr. Gardiner, as officer and never-failing friend, to the Marine Biological Laboratory. His long connection with laboratory affairs and intimate knowledge of its history made him one of the most important members of the board of trustees, and his high standing in Boston enabled him to secure valuable assistance for the promotion of the interests of the laboratory.

The board of trustees of the Marine Biological Laboratory record their sorrow at his untimely death, their sense of great loss, and their admiration for the fine sense of honor and loyalty that characterized his life. And they order this record spread upon the minutes of the board of trustees, and recommend that it be published, and that copies be sent to his family, near relatives and friends to express

the sympathy of the board in their bereavement.

ORIGINAL PUBLICATIONS OF EDWARD G. GARDINER

"Beiträge zur Kenntniss des Epitrichiums und der Bildung des Vogelschnabels," Inaugural-Dissertation, Leipzig, 1884. Also in *Archiv für Mikroskopische Anatomie*, Bd. XXIV., 1885, pp. 289–338, Taf. XVII.–XVIII.

"Notes on the Structure of the Quills of the Porcupine," *Technology Quarterly*, Vol. I., p. 392, 1889.

"The Origin of Death," *Technology Quarterly*, Vol. IV., p. 178, 1891.

"Weismann and Maupas on the Origin of Death," Biological Lectures delivered at the Marine Biological Laboratory of Woods Hole, Vol. I., Ginn & Co., Boston.

"Early Development of *Polychœrus caudatus*, Mark," *Journal of Morphology*, Vol. XI., No. 1, pp. 155–171, 1895.

"The Growth of the Ovum, Formation of the Polar Bodies and Fertilization in *Polychœrus caudatus*," *Journal of Morphology*, Vol. XV., No. 1, pp. 73–110, Plates 9–12, 1898.

For a number of years prior to his death Dr. Gardiner had been engaged upon a monograph of the *Turbellaria acœla*, which was to have been his principal scientific work, but which was never completed.

SCIENTIFIC NOTES AND NEWS

As we have already announced would be the case, Sir E. Ray Lankester relinquished the directorship of the Natural History Departments of the British Museum on December 31. The trustees have not yet appointed a new director of these departments and it appears to be very uncertain whether they have any intention of doing so. The keepership of the Zoological Department, which was also held by Sir Ray Lankester, likewise remains unfilled.

M. BOURGET, of the Toulouse Observatory, has been appointed director of the Marseilles Observatory, to succeed M. Stephan, who has retired.

THE council of the Institution of Electrical Engineers has elected Lieutenant-Colonel R. E. B. Crompton, C.B., to the presidency of the institution, vacant by the death of Lord Kelvin.

PROFESSOR R. S. LULL, curator in vertebrate paleontology, Peabody Museum, Yale University, was elected president of the American Society of Vertebrate Paleontologists at the meeting in New Haven on December 28.

PROFESSOR MARSTON T. BOGERT, of Columbia University, has been elected president of the Chemists' Club, New York.

THE council of the Geological Society of London has made the following awards: the Wollaston medal to Dr. Paul Groth, professor of mineralogy in the University of Munich; the Murchison medal to Mr. A. C. Seward, professor of botany in the University of Cambridge; the Lyell medal to Mr. R. D. Oldham, formerly of the Geological Survey of India; the Wollaston Fund to Mr. H. H. Thomas, of the Geological Survey of England; the Murchison fund to Miss Ethel G. Skeat, while the Lyell fund is divided between Mr. H. J. Osborne White and Mr. T. F. Sibly for their respective work on the Cretaceous and Carboniferous rocks of England.

THE Liverpool School of Tropical Medicine has decided to confer the Mary Kingsley memorial medal on Mr. Joseph Chamberlain "in recognition of the great work he inaugurated by the establishment of schools of tropical medicine."

MR. MORRIS K. JESUP, president of the American Museum of Natural History, has been made a corresponding honorary member of the Senckenbergische Naturforschende Gesellschaft in appreciation of his gift of the Diplodocus skeleton to the Senckenberg Museum at Frankfurt on the Main, Germany.

DR. EMIL FISCHER and Dr. J. H. van't Hoff, professors of chemistry in the University of Berlin, have been given the honorary degree of doctor of engineering by the Technical Institute at Brunswick.

WE learn from *Nature* that Sir Norman Lockyer has been unanimously elected president and an honorary member of the Penzance Natural History and Antiquarian Society in recognition of his services to the study of the circles and other prehistoric remains in west Cornwall.

M. M. Nyrén, of the Pulkowa Observatory, retired from his office at the end of 1907.

Professor F. B. Crocker, head of the department of electrical engineering in Columbia University, has been appointed secretary of the American section of the international electrotechnical commission, which includes representatives from twelve of the principal countries. This commission has undertaken the universal standardization of electrical machinery and apparatus.

The fifth lecture in the Harvey Society course will be delivered by Professor George W. Crile of the Western Reserve University, at the New York Academy of Medicine building on January 25, at 8:30 p.m. Subject: "Shock." All interested are cordially invited to be present.

Dr. C. P. Steinmetz recently lectured at the University of Illinois, on alternating current railway motors. The meeting was under the auspices of the Urbana Section of the American Institute of Electrical Engineers.

A series of twelve lectures on Nutrition: digestion, metabolism and selection of foods, will be given at Teachers College, Columbia University, beginning on January 13, 1908, and weekly thereafter. The lectures will be given by Dr. William J. Gies, of the College of Physicians and Surgeons, Dr. Henry C. Sherman, of the School of Chemistry and Teachers College, and Miss Anna Barrows, of the department of domestic science, Teachers College.

The deaths are announced of Dr. P. Lachmann, professor of botany at Grenoble at the age of fifty-six years, of Dr. A. W. Krassnow, professor of astronomy and director of the observatory at Warsaw, at the age of forty-one years, and of Dr. H. Giessler, formerly professor of chemistry at Stuttgart Chemical Institute at the age of sixty years.

The U. S. Civil Service Commission announces an examination on February 5–6, to fill vacancies as they may occur in the position of topographic aid, in the Geological Survey, at salaries ranging from $840 to $1,200 per annum, depending upon the experience and ability of the applicant, and in other branches of the service. It also announces an examination on February 5 to fill a vacancy in the position of scientific assistant, $720 per annum, in the Bureau of Fisheries, and vacancies requiring similar qualifications as they may occur.

Senator Dick, of Ohio, introduced in the senate on January 15 a joint resolution to provide for a Mining Technology Branch in the Geological Survey and a bill for the establishment of a Bureau of Mining Technology.

Mr. Smith, of California, has introduced in the house of representatives a bill for the protection of animals, birds and fishes, in the forest reserves in California, which was referred to the committee on the public lands.

The city of Berlin has appropriated $12,500 toward the fund for combating tuberculosis to be named in honor of Dr. Robert Koch. About $40,000 have been subscribed from private sources.

At the examinations recently held in Peking for official degrees men who had studied in American universities were awarded the highest honors. Out of a large number examined, only seven were given the highest degree obtainable, and of these five were graduates of the University of California, while the other two had studied in Japan.

The third meeting of the Commission for the Study of Problems relating to Human Nutrition, appointed by the University of Illinois, was held at the university, Urbana, December 27–28. All the members of the commission were present, including Dr. Theobald Smith, of Harvard; Professor Chittenden, of Yale; Professor Abel, of Johns Hopkins; Professor A. P. Mathews, of the University of Chicago, and Professor Grindley, of the University of Illinois. The commission considered fully the detailed plans at present being used in connection with the nutrition investigations which are being made at the University of Illinois in the study of the influence of cured meats upon the health of man. They also thoroughly inspected the laboratories, the equipment and the houses used for the experiments. The members of

the commission visited the nutrition club, taking two meals with the members. The work already done was approved, and arrangements were made for extending in several ways the scope of the investigation now in hand.

AMERICAN geologists who are interested in modern interpretations of Alpine structure will find a valuable series of colored sections in several pamphlets by Professor C. Schmidt, of Basel, as follows: "Bild und Bau der Schweizeralpen," which appeared as a supplement to Vol. XLII. of the Swiss Alpine Club, 1907 (Finckh, Basel, 5 francs), contains, besides a beautifully illustrated text, a small geological map and a remarkable group of sections illustrating the extreme extension now given to the idea of overthrust folds. "Führer zu den Exkursionen der deutschen geologischen Gesellschaft im südlichen Schwarzwald, im Jura und in den Alpen," August 1907, by Schmidt, Buxtorf and Preiswerk (Schweizerbart, Stüttgart, 5 Marks), containing a number of more detailed sections, as well as the same group of general sections. "Ueber die Geologie des Simplongebietes und die Tektonik der Schweizeralpen" (Eclog. geol. helv., IX.), with a number of detailed sections and a general geological map of the Alps between St. Gotthard and Mont Blanc. "Tektonische Demonstrationsbilder" (to be had of the author, 1 franc), with some of the same Alpine sections and several additional sections for the Vosges and the Schwarzwald.

WE learn from the *British Medical Journal* that Mr. Young J. Pentland, of Edinburgh, has relinquished his publishing business in favor of Mr. Henry Frowde, Oxford University Press, and Messrs. Hodder and Stoughton. The copyright volumes transferred include the well-known "Text-book and Manual of Anatomy," by Professor D. J. Cunningham; the "Text-book of Physiology," by Professor Schäfer; the "Manual of Bacteriology," by Professors Muir and Ritchie; the "Manual of Surgery," by Messrs. Thomson and Miles; the "Outlines of Zoology," by Professor J. Arthur Thomson, etc. These works will for the future be published by Mr. Frowde and Messrs. Hodder and Stoughton.

A NEWSPAPER despatch from San Francisco states that with only seven cases of plague reported during the month of December and but three cases remaining under treatment at the isolation hospital, bubonic plague in San Francisco is almost eradicated as a result of the vigorous sanitary campaign conducted during the past four months, by the United States Marine Hospital Service, under the direction of Dr. Rupert Blue, and with the cooperation of the local health authorities. Dr. Blue's staff consists of Dr. W. C. Bucker, his executive officer, and fourteen medical officers from the Marine Hospital Service. Over $200,000 has been expended in a campaign of sanitation and the monthly payroll at present is about $43,000, of which the federal government is paying three fourths. It is estimated that approximately 130,000 rats have been destroyed during the past four months. Thirty-five thousand six hundred and forty-two rats were brought to the laboratory of the health department. Of this number, 11,391 were examined by bacteriologists for plague and 106 found to be infected. The total number of cases reported to date are 136; deaths 73; cured 60, remaining under treatment 3.

CONSUL-GENERAL RICHARD GUENTHER reports that a "Trade Hygienic Institute" is to be established in Frankfort, where all matters appertaining to the health and protection of German factory operatives and the working classes in general are to be studied and taught. He continues: "This institution will be the first of its kind and will have a highly important mission and a great field in which to work. Frankfort has been chosen on account of its being in close proximity to some of the great chemical factories, technical high schools and universities, and the many economic and social-scientific associations abounding in this city and vicinity. The 'Institute for Communal Advancement' in Frankfort, aided by contributions from prominent manufacturers, has raised 100,000 Marks ($23,800) as an endowment for this 'Trade Hygienic Institute.' All the data concerning experiments and experience of physicians and others employed or interested in the care for the working classes,

also all reports emanating from official trade inspections, of labor associations, etc., is to be collected by this new institute, where they will be examined by experts and put to good use. Extensive laboratories fitted up with the best of modern appliances will be erected. This enterprise has its source in the belief held by its organization that a central point for this kind of science will greatly benefit the chemical and other industries, and especially the working classes connected therewith."

The College of Agriculture of Cornell University will have a convention of farmers between February 17 and 22. The object of this meeting is to give practical demonstrations of the aims, methods, and results of the work of the college. At the same time will be held the annual meetings of the New York Poultry Society and of the State Agricultural Experimenters' League.

The Bausch & Lomb Optical Company of Rochester, and the Bausch, Lomb, Saegmuller Company of that city, and the Carl Zeiss Optical Works of Jena, Germany, have united their interests, with the expressed purpose of carrying to the highest possible development the production of optical, physical and engineering instruments. The Zeiss works became under Professor Abbe a scientific institution, as well as a commercial firm. They now employ some thirty experts engaged in scientific research, and it will be fortunate if similar methods can be followed in this country.

The United States Geological Survey's annual report on the mineral resources of the United States for 1906 is now ready for distribution. The separate chapters of this volume have been published from time to time as the statistics for the various minerals became available, and these assembled chapters form a book of 1,300 pages, provided with a table of contents, an introduction and an index. The volume comprises 47 separate reports, prepared by 27 authors, covering entirely the mineral production of the country, with descriptions and discussions of the deposits from which the minerals are obtained, reports of imports and exports and many comparisons of home and foreign production, statements of prices and prospects, and notes on the technology of many of the products. In its general features this volume is similar in form and scope to the preceding reports on mineral resources published by the Geological Survey, the series covering altogether a period of twenty-seven years. For twenty-five years of this period the work of gathering these statistics has been in charge of Dr. David T. Day, but the present volume has been prepared in part under the supervision of Mr. Edward W. Parker, who has been for many years Dr. Day's assistant and collaborator. Hereafter Dr. Day will give his attention chiefly to the compilation of reports on petroleum and natural gas, substances concerning which accurate information has been difficult to obtain, and Mr. Parker will have administrative charge of the work of collecting and compiling the various reports and statistics that are published in this annual volume. Since the survey began its work on the mineral statistics of the country the value of the mineral production has increased more than fivefold. From $364,928,298 in 1880 it has risen gradually, with some fluctuations, to $1,902,517,565 in 1906, a sum representing the value of the mineral products in their first marketable condition. The larger producing states contributed to this total in 1906 in the following order and approximate proportions: Pennsylvania, 30 per cent.; Ohio, 11 per cent.; Illinois, 6 per cent.; New York and West Virginia, 4 per cent. each; Montana, Colorado and Michigan, 3.5 per cent. each; Arizona and Missouri, 3 per cent. each; Alabama and California, 2.5 per cent. each. The value of the mineral output of each of these twelve states was more than $50,000,000, and their combined values amount to more than $1,488,000,000.

In his annual report the Secretary of Agriculture says in regard to the new building for the department: "The work on the new building for the department has progressed satisfactorily during the year, and it is hoped to occupy the new quarters within the next month or two. As pointed out in my last report, in considering the question of a building, the imperative need for suitable labora-

tories to carry on the important investigations of the various bureaus and fireproof space for the library was recognized as paramount. The greater part of the indoor work of the department is conducted in laboratories, hence the absolute necessity for structures that would be well lighted, well ventilated, fireproof, and otherwise well adapted for the purpose. To accomplish these several objects and at the same time to secure opportunities for continued enlargement, the building has been arranged so that extensions could be made in segments as the work required. When the act authorizing the building was passed we could not foresee the rapid growth, by congressional action, of the department. On February 3, 1903, when the work was authorized, there were in Washington 1,100 persons employed in the Department of Agriculture. At the present time there are over 2,100—almost double the number on the date when the appropriation was made. While the original appropriation was so expended as to secure the greatest possible amount of floor space, this floor space is now totally inadequate to care for the increase of almost 100 per cent. in the number of employees. Full arrangements have been worked out for the occupancy of the present segments and the relinquishment of the several buildings for which rent is now being paid. The work will be completed within the appropriation made by Congress."

PROFESSOR J. A. ALLEN makes the following note in a recent *Bulletin of the American Museum of Natural History* on the revision of the nomenclature code by the International Zoological Congress: "As time goes on, the importance of strict adherence to authoritative rules of nomenclature becomes more and more apparent. Hence the world-wide welcome accorded the work of the Nomenclature Commission of the International Zoological Congress, and the increasing cordiality with which its Code of Nomenclature is received. The time is doubtless now ripe for the acceptance on the part of zoologists at large of an International Arbitration Commission on Nomenclature which shall not only provide a code of official rules, but be willing to act as arbiter in difficult and complicated cases where experts may reach different conclusions. To most systematists questions of nomenclature are distasteful, and they would gladly accept the decisions of a properly authorized International Commission rather than fritter away valuable time in attempting to solve nomenclatural riddles. Success in this thankless line of work requires natural aptness for such investigations, coupled with long experience and interest in such work. Nine tenths, if not ninety-nine one hundredths, of those who have occasion to use the technical names of animals, have not the time, the inclination, nor the proper training to deal successfully with such problems. Yet their correct solution is of importance to all. The adoption of uniform rules of nomenclature is essential to stability in nomenclature, but if they contravene well-established principles that have become the basis of modern usage they are not likely to meet with general acceptance. Happily the fundamental rules of nomenclature are few, and for many years have been embodied in all modern codes of nomenclature. Matters of detail are of less importance than unanimity of agreement, which may be easily reached by compromise and the waiving here and there of personal preference on minor points."

UNIVERSITY AND EDUCATIONAL NEWS

FROM a source not yet announced, the Harvard Dental School has received promise of the funds necessary for the erection of a new building. The site which has been chosen is the lot at the corner of Longwood Avenue and Wigglesworth Street, Brookline, adjoining the property on which the buildings of the Medical School stand.

A NEW agricultural building is to be erected for the University of Maine, at a cost of about $35,000.

PRESIDENT EDMUND J. JAMES, of the University of Illinois, has issued a call for a national conference to meet at Urbana, Ill., on February 4 and 5, to discuss the relations of graduate schools of American universities to the preparation of teachers for high schools, colleges and universities.

The National Society for the Promotion of Industrial Education will hold a meeting in Chicago on January 23, 24 and 25. A full program has been arranged. Among the subjects that will be discussed are the apprenticeship system, the trade school, the wage-earners benefit from industrial education, and the ideal of a public school system that aims to benefit all. Among the speakers are Dr. Pritchett, of the Carnegie Foundation, president of the society; President Eliot, of Harvard University, and President Wheeler, of the University of California.

The fourth annual report of the education department of New York State has been transmitted to the legislature. The amount expended for the common schools for the year was $47,077,720, an increase of $1,694,168. There were employed in the public elementary schools during the year 37,280 teachers—3,292 men and 33,988 women. The average annual salary paid was $756.10, an increase of $10.61.

The New York Evening *Post* states that plans for beautifying the surroundings of the Harvard Medical School have been accepted by the Medical School and the Street Department of Boston. Starting from a terminal point in the Fenway near a small lagoon, the new avenue in honor of Louis Pasteur will lead up to the middle of the Medical School quadrangle. This avenue will run through the center of a parkway 120 feet wide. An entrance will be constructed at the junction of the parkway with the quadrangle of the school. The new laboratory on Longwood Avenue, near the Medical School—being built by the Carnegie Institution of Washington for the study of nutrition—will be completed on February 1.

The Baltimore Association for the Promotion of the University Education of Women offers a fellowship of $500 for the year 1908–1909 available for study at an American or European university. Applications must be in the hands of the chairman of the committee, Dr. Mary Sherwood, The Arundel, Baltimore, before March 20.

Mr. E. M. Griffith, the state forester of Wisconsin, will give a course of sixteen lectures on forestry to the students of the University of Wisconsin during the second semester. The lectures are intended for those who expect to manage timber lands or take up forestry as their profession; for students in the agricultural college, to afford information in regard to the management of wood lots; and for students in the college of engineering who are interested in soil reclamation and the protection of stream flow and water powers. The subjects included in the course are the effects of deforestation, conservative lumbering, artificial and natural reforestation, the reservoir system on the headwaters of the Wisconsin, the forest fire problem, taxation of timber lands, forestry for farmers, and forestry legislation.

At a recent meeting of the board of trustees of the Iowa State College Mr. C. A. Scott, of the United States Forest Service, was elected to the chair of forestry, to fill the vacancy caused by the resignation of Professor H. P. Baker, who accepted a position at the Pennsylvania State College. Mr. Scott is a graduate of the Kansas State Agricultural College and a student of the Yale College of Forestry. Mr. Scott has been continuously in the employment of the Forest Service since graduation and during this period of seven years has gradually advanced through all stages of the work from that of student assistant to forest supervisor, which position he resigned to accept the chair of forestry at the Iowa State College.

The corporation of Harvard University has appointed Herbert Leslie Burrell, now professor of clinical surgery, John Homans professor of surgery.

Dr. George T. Jackson has been appointed professor of dermatology in Columbia University to succeed Dr. George H. Fox, who has resigned.

Correction: In the report of the general secretary of the American Association for the Advancement of Science there is an error on page 43. Sections A and D joined with the Chicago section of the American Mathematical Society in the discussion of the teaching of mathematics to engineers, not A and B, as appears in the report.